

Handbook for Training Field Extension and Technical Assistance Personnel **TUSKEGEE** UNIVERSITY Cooperative Extension Program

Sustainable Year-Round Forage Production and Grazing/Browsing Management for Goats in the Southern Region



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PREFACE

About the Handbook

This handbook has been developed to train field-level Extension and technical assistance personnel (hereafter field personnel), who are involved in educating and helping goat producers in the Southern Region. The purpose of developing this handbook is to extensively increase the training and educational opportunities for goat producers in the Southern Region on sustainable year-round forage production and grazing/browsing management. Goat production in this Region is mostly based on pastures; however, a majority of the goat producers do not have productive pastures despite the Region's favorable climatic conditions for year-round forage production.

A wide range of topics relevant to year-round forage production and grazing/browsing management, specifically focusing on goats, are included in this handbook with 14 different chapters. Chapter 1 highlights the importance of year-round forage production and its sustainable management. Chapter 2 presents the definition and classification of forages. Agronomic aspects such as soil test, lime and fertilizer application, land preparation, forage selection, inoculation of legume seeds, and forage establishment have been presented in Chapter 3. This chapter also includes forage physiology, stockpiling program, and forage quality and testing. Chapter 4 discusses on grazing behavior of animals and their influence on pastures, and different grazing systems. Various structures and facilities such as perimeter and cross-fencing, shelter, facilities for goat handling, feeding, and watering that are required for a pasture-based goat operation are presented in Chapter 5. Important aspects of sustainable grazing management such as time to begin and end grazing different types of forages, grazing and resting periods required for forages, harmful effects of inappropriate grazing, and suitable grazing systems and management strategies to match the given pasture situations have been discussed in Chapter 6. Common predators and their identification and management strategies have been presented in Chapter 7. Chapter 8 includes strategies on disaster preparedness and handling disaster aftermath for livestock including goats. Chapter 9 presents the descriptions and benefits of common browse species adapted to the Southern Region and their sustainable management strategies. Different types of supplementary feeds for grazing goats, and their selection and feeding schemes have been discussed in Chapter 10. The identification, biology, and management tactics of pasture weeds are presented in Chapter 11. Chapter 12 presents the concept and type of erosion that can occur under a grazing situation, and conservation planning to mitigate erosion. Common parasites and diseases of goats under grazing/browsing condition, and their management approaches have been described in Chapter 13. Chapter 14 consists of basic economic concepts, record keeping, and some economic calculations and analyses taking few examples of goat operation before and after pasture improvement. Most of the chapters include hands-on activities to be incorporated during the training sessions. When field personnel are trained by subject matter specialists on the content of this handbook, including the hands-on activities, these field personnel are expected to be able to conduct similar training sessions for goat producers in their working areas by using this handbook as a guide. Field personnel can also use this handbook as a reference material to develop various fact sheets and articles to fulfill the needs of their clientele.

Acknowledgements

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Uma Karki, Ph.D. Editor

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CHAPTER 1 IMPORTANCE OF YEAR-ROUND FORAGE PRODUCTION AND GRAZING/BROWSING MANAGEMENT

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Introduction

Pasture is a land unit that is managed for grazing, and usually separated from other types of land units by fencing or other barricade (Barnes et al., 2007). Year-round pasture is productive throughout the year making forage available for year-round grazing. Different forages suitable to the soil types and climatic conditions of the given pasture can be planted and managed sustainably for year-round grazing. Moreover, for goat pastures, several volunteer grasses, legumes, forbs, briers, vines, and shrubs can be managed in the pasture along with the planted forages because goats like variety in their diet. Several kinds of briers, forbs, vines, and shrubs that are generally avoided by cattle and other livestock species are readily eaten by goats. Furthermore, available woodlands can be used with appropriate fencing or developed into a silvopasture system if the situation permits to expand the grazing opportunity. When done appropriately and pastureland is not a problem, goat production based on year-round pasture can be more economical, time saving, and environment friendly compared to that based on seasonal pastures of most of the goat producers, especially limited resource producers, in the Southern Region are low productive and dominated with seasonal perennial grasses.

Year-Round Pasture Promotes Sustainable Goat Production

Economic Sustainability

Quality, productive year-round pastures offer goats plenty of forages to fulfill their nutrient requirements. It is always less costly when goats can harvest forages according to their needs rather than feeding them manually irrespective of the type of feeds because of the following reasons:

- Manual feeding involves extra costs to buy feedstuffs and develop feed storage facilities as well as requires extra hours of work to feed goats.
- Also, extra costs are incurred from possible loss of feedstuffs while storing and feeding. There can be a huge loss in hay dry matter when improperly fed or stored. Thirty percent or higher loss of hay dry matter may occur when stored unprotected in an open field (Ball et al., 2007). Kallenbach (2000) has pointed out that storage and feeding loss of hay dry matter may reach 50 percent or higher when special care is not taken to minimize such loss.
- Manual feeding can be more costly to limited resource goat producers compared to big buyers. It is because the former usually lack enough storage facility and required funds to buy feedstuffs in a bulk at times when there is a plenty of supply and price is low. As

a result, they have to buy feedstuffs in smaller amounts and when they actually need it, basically during the winter when there is a limited supply of feedstuffs and the price is usually high.

Limited resource goat producers may make negligible or no money when cost of production increases with the fluctuating market price for goats and goat products. The chance of making a good profit for limited resource producers remains low as their herd size is usually small. Increasing the productivity, quality, and production duration of the existing pasture will provide a better feeding option and minimize the requirement of supplementary feeding. This will make the system economically more viable compared to that associated with low productive pastures. Also, when the pastureland is more productive, producers will be able to hold more animal unit per acre and augment their profits. Two goat producers from Alabama shared (personal communication) that they tremendously reduced production costs by developing and managing winter pastures during the 2012 cool-season grazing period.

Environmental Sustainability

Besides economic benefits, year-round pastures offer better environmental quality compared to seasonal pastures. Development of year-round pastures requires the incorporation of different types of annual and perennial grasses and legumes into the existing pastures. Inclusion of a wide variety of forages into pastures will increase biodiversity, which promotes sustainability (Isbell et al., 2009; Tilman et al., 2006). Incorporation and maintenance of cool-season species into the warm-season perennial pasture will provide higher level of vegetation coverage to the pastureland for an extended period and reduce the risk of soil erosion (Zhou et al., 2008; Zhou and Shangguan, 2007). Similar to warm-season pastures, cool-season perennial grass pastures can be improved by overseeding with suitable legumes and annual grasses.

Incorporation and maintenance of legumes into the pasture system will replace the requirement of commercial nitrogen fertilizer application and enhance soil quality; this will save money and promotes land productivity in the long run. Legumes help make the system self-sustaining by fixing atmospheric nitrogen into the system. Specific *Rhizobium* bacteria colonize the legume roots and fix nitrogen by taking carbon from the host plant while supplying the fixed nitrogen to the host plants. The amount of nitrogen fixed (lbs $ac^{-1} yr^{-1}$) varies depending on the forage species and environmental conditions; however, the amount of nitrogen fixation ranges from 50 to 150 for a good stand of annual clovers and vetches; 75 to 200 for birdsfoot trefoil (*Lotus corniculatus*), white clover (*Trifolium repens*), and red clover (*Trifolium pretense*), and 150 to 200 for alfalfa. Grasses grown together with legumes comprising 33 percent or more of the forage stands do not need nitrogen fertilization (Ball et al., 2007). Also, introduction and maintenance of legumes into the system is more economical than applying commercial nitrogen fertilizer for the present market price (Prevatt, J.W., unpublished). Moreover, legume crops can enhance soil quality indicators.

Karki et al. (2009) reported lower penetration resistance of soils at 10-15 and 15-20 cm depth in bahiagrass plot overseeded with crimson clover for two years versus an adjacent sole bahiagrass plot that received 60 pounds/acre of commercial nitrogen fertilizer annually. Penetration resistance is a measure of soil compaction and is related to pore-space, and therefore impacts infiltration, air and water movement, and root growth (Stephenson and Veigel, 1987). Higher

porous structure of soil is desirable for better growth and development of plant roots, nutrients and water uptake by plants, and microbial activity, which is very important for maintaining soil health (Kay and Angers, 2000). Haynes and Beare (1997) found higher aggregate stability, another soil quality indicator, under lupin (*Lupinus augustifolius*), white clover, and Italian ryegrass (*Lolium multifloium*) as compared to other non-legume species studied. All these findings indicate that incorporation and maintenance of legumes into pastures enhance the soil quality, promote healthy environment, and increase the long-term land productivity.

Well-managed year-round pastures minimize the chance of overgrazing and make the pasture system more sustainable. Overgrazing can inflict untoward effects on plants by repeated defoliation and trampling. Continued overgrazing of tall-growing forage generally weakens plants resulting in reduced root systems, lower forage yield, higher soil erosion and water runoff, and increased weed invasion. Also, there can be significant negative impacts of overgrazing on soil by contributing to soil compaction and creating smaller macroporosity, loss of pore continuity, greater bulk density, and pugging and puddling of soil when water content is high (Chen and Cui, 2001; Southorn and Cattle, 2004). Besides minimizing the risk of overgrazing, year-round pastures will lower the costs of production and promote economic sustainability. As already mentioned, feeding livestock with supplementary feed is more expensive than grazing. Development of an appropriate grazing system to manage the multi-species pasture will provide an option for farmers to maximize profits in a sustainable way.

Year-Round Pasture is the Gateway to Naturally Grown, Grass-Fed, or Organically Produced Goats and Goat Products

With increasing public health consciousness, demand for healthier livestock products such as naturally grown, grass-fed, or organically produced livestock and livestock products is increasing. The Organic Trade Association (OTA) (2011) claimed that 78 percent of the US families were buying organic products in 2011 and four out of 10 US families increased the purchase of organic food in 2011 compared to a year before. USDA-ERS (2012), referring to the industry data, mentioned that the demand for organically produced goods increased by double digits over a decade with organic food accounting for three percent of the total US food sales. In 2008, there were little more than two million acres of pasture/rangeland (245% higher than in 2002) and about half a million of livestock head (339% higher than in 2002) were organically certified throughout the USA (USDA-ERS, 2012a). Although there is not much data available on organically produced, grass-fed, or naturally grown goats, the trend in overall agriculture indicates that the demand for healthy food products is increasing. This provides opportunity for goat producers to be proactive and improve their production system to comfortably compete in the emerging market demand. Development and management of year-round pastures that support year-round grazing is the foundation for transitioning the traditional production system (only targeting the traditional market) to a healthier production system oriented towards health conscious consumers, who are going to hold future market demand.

Appropriate Grazing/Browsing Management is Necessary to Sustain Pastures

Once the pastures are improved by planting different cool-season and warm-season grasses and legumes, these have to be managed well with a suitable grazing plan such that each forage

species included in the pasture can have a good environment in which to survive and persist. Different forage species have different growth patterns, food storage structures and capacities, root structures, shade tolerances, and so on. Because of these variations, some species tolerate more grazing pressure compared to the others. Therefore, mixed-species pastures are generally control-grazed with a suitable grazing system such as rotational grazing, strip grazing, and limit grazing. Detailed information about forage classification, forage physiology, grazing effects on pastures, and different grazing systems is presented in the following chapters.

Forage Production is Weather Dependent

Weather condition has a very important role on pastures in terms of establishment success, productivity, quality, and persistence. Therefore, while planning a pasture development or improvement program, forage species that would fit the expected weather condition should be selected and planted at the right time when there is enough moisture for their germination and growth. Provision of irrigation will be very helpful to avoid the detrimental effects of drought on forages. When weather does not cooperate, developing and maintaining a year-round forage production system can be a challenge.

Key Points

- 1. Good, productive pasture is the basis for sustainable ruminant livestock production, including goats.
- 2. Goat production based on productive, year-round pastures that support year-round grazing is more economical and environment friendly compared with seasonal pastures that require supplementary feeding.
- 3. Year-round pastures for goats can be developed by planting a combination of suitable cool-season and warm-season grasses and legumes.
- 4. Natural vegetation present in the grazing land and woodland can be utilized for increasing the grazing opportunity for a goat herd.
- 5. Proper grazing management is necessary for maintaining persistent, productive pastures.

References

- Ball, D. M., C. G. Hoveland, and G. D. Lacefield. 2007. Southern forages. 4th ed. The International Plant Nutrition Institute (IPNI), Norcross, GA.
- Barnes, R. F., C. J. Nelson, and G. W. Fick. 2007. Terminology and classification of forage plants. In: R. F. Barnes, C. J. Nelson, K. J. Moore and M. Collins, editors, Forages: The science of grassland agriculture, No. II. Blackwell publishing, Ames, IA. p. 1-14.
- Chen, Z., and X. Cui. 2001. Impact of grazing on soil properties in steppe ecosystems. In: M. Shiyomi and H. Koizumi, editors, Structure and Function in Agroecosystem Design and Management. CRS Press Inc., Boca Raton, FL. p. 315-333.
- Haynes, R. J., and M. H. Beare. 1997. Influence of six crop species on aggregate stability and some labile organic matter fractions. Soil Biol. Biochem. 29:1647-1653.
- Isbell, F. I., H. Wayne, P. Wilsey, and B. J. Wilsey. 2009. Biodiversity, productivity and the temporal stability of productivity: patterns and processes. Ecol. Lett. 12:443-451.

- Kallenbach, R. 2000. Reducing losses when feeding hay to beef cattle. MU Extension, University of Missouri-Columbia. Accessed Dec. 9, 2012. <u>http://extension.missouri.edu/publications/DisplayPub.aspx?P=G4570</u>.
- Karki, U., M. S. Goodman, and S. E. Sladden. 2009. Nitrogen source influences on forage and soil in young southern-pine silvopasture. Agr. Ecosyst. Environ. 131:70-76.
- Kay, B. D., and D. A. Angers. 2000. Soil structure. In: M. E. Sumner, editor, Handbook of soil science. CRC press, Boca Raton, LA. p. A229-A276.
- OTA, Organic Trade Association. 2011. 2011 press releases. Accessed Jul. 11, 2012. http://www.organicnewsroom.com/2011/11/seventyeight percent of us fam.html
- Southorn, N., and S. Cattle. 2004. The dynamics of soil quality in livestock grazing systems. Third Australian New Zealand Soils conference. SuperSoil 2004, University of Sydney, Australia. Accessed Oct. 10, 2012.

www.regional.org.au/au/pdf/asssi/supersoil2004/1789_southornn.pdf

- Stephenson, G. R., and A. Veigel. 1987. Recovery of compacted soil on pastures used for winter cattle feeding. J. Range Manage. 40:46-48.
- Tilman, D., P. B. Reich, and J. M. H. Knops. 2006. Biodiversity and ecosystem stability in a decade-long grassland experiment. Nature. 441:629-632.
- USDA-ERS, US Department of Agriculture, Economic Research Service. 2012. Organic market overview. Accessed Jul. 11, 2012. <u>http://www.ers.usda.gov/topics/natural-resources-</u> environment/organic-agriculture/organic-market-overview.aspx
- USDA-ERS, US Department of Agriculture, Economic Research Service. 2012a. Table 2. U.S. certified organic farmland acreage, livestock numbers, and farm operations. Accessed Sept. 9, 2012. <u>http://www.ers.usda.gov/data-products/organic-production.aspx</u>
- Zhou, P., O. Luukkanen, T. Tokola, and J. Nieminen. 2008. Effect of vegetation cover on soil erosion in a mountainous watershed. Catena. 75:319-325.
- Zhou, Z. C., and Z. P. Shangguan. 2007. The effects of ryegrass roots and shoots on loess erosion under simulated rainfall. Catena. 70:350-355.

CHAPTER 2 FORAGE DEFINITION AND CLASSIFICATION

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Introduction

Forage is any portion of plants, except separated grains, that is eaten by animals to fulfill their nutrient requirements, or that harvested as animal feed (Barnes et al., 2007). So, forage include leaves, twigs, stems, branches, roots, and all other plant parts edible to animals. There are several kinds of forages, and these are classified in different ways based on their woodiness and size, structure, growth pattern, life span, and suitable growth season. Each of these classifications is briefly described below.

Herbs, Shrubs, and Trees

Herbs are small plants with soft stems and most leaves; examples are grasses, clovers, and forbs. **Shrubs** are intermediate between herbs and trees. These are woodier and larger than herbs, but smaller and less woody than trees. Groundsel, rose, and blackberry are examples of shrubs. **Trees** are most woody with big trunk, and they are the largest among all. Examples are pine trees, oak trees, mulberry trees.

Grasses, Legumes, and Forbs

Grasses are monocots; they produce single seed leaf, and have parallel leaf venation. Examples are corn, bahiagrass, bermudagrass, rye, wheat, oats, and ryegrass (Fig. 2.1b). Legumes are dicots; they produce two seed leaves, have reticulate leaf venation, and bear seeds in pods. A few examples are clovers, peas, beans, sericea lespedeza, and kudzu (Fig. 2.1a). Grasses are a good source of energy while legumes are a good protein source. Legume roots are colonized by Rhizobium bacteria, form root nodules, and fix nitrogen (Fig. 2.2 and Fig. 2.3). Different legumes have specific Rhizobium bacteria, so while introducing legumes into a new field, legume seed must be inoculated properly to establish the stand successfully and get good production. Because of the nitrogen fixing ability of legumes, when grasses and legumes are grown together with a legume stand comprising of 33 percent or more of the pasture, application of nitrogen fertilizer may not be necessary - so money is saved. Amounts of nitrogen fixed (lbs ac⁻¹ yr⁻¹) vary depending on the forage species and environmental conditions as mentioned earlier (Chapter 1, page 3). For a good nitrogen fixation, there must be enough mineral nutrients such as calcium, molybdenum, iron, sulfur, phosphorus, and copper; good moisture should be available (25 to 75% of field capacity), but a water logging condition has an adverse effect; pH should be favorable for the given legume crops; low pH is unfavorable.



Figure 2.1. Examples of dicot and monocot seeds, seedlings, and leaf: (a) Bean and (b) Corn. Source: Adapted from Karki and Gurung, 2009.

Forbs are herbaceous plants that are neither grass nor legume. Examples are chicory, pokeweed, dandelion, horseweed, and iron weed.



Figure 2.2. Root nodules on effectively inoculated white clover. Source: http://www.dpi.nsw.gov.au/ data/assets/image/0008/157490/fig2-innoculating.jpg

Annuals, Biennials, and Perennial Species

Annual forages grow and mature during favorable seasons and die at the end of the season within a year. Examples are annual ryegrass, wheat, oats, cowpea, soybean, and crimson clover. Some annuals, if managed properly, can reseed, so they may not need to be planted every year. However, if harvested before seeds are mature and dropped into the soil, annuals need to be planted each year. **Biennials** produce for two years once established, with vegetative growth in the first year and reproductive growth in the second year. These need replanting every other year unless they are good reseeders. **Perennial** forages survive for several years – they grow and mature in favorable seasons and become dormant during off-seasons. Examples are bahiagrass, bermudagrass, dallisgrass, johnsongrass, switchgrass, white clover, and sericea lespedeza. Once established successfully and managed properly, perennials produce during favorable seasons for several years.



Figure 2.3. Nitrogen fixation and the fate of fixed nitrogen. Source: <u>http://upload.wikimedia.org/wikipedia/commons/thumb/d/de/Nitrogen_Cycle.jpg/400px-Nitrogen_Cycle.jpg</u>

Prostrate, Semi-Erect, and Erect Species

Prostrate species crawl on or remain close to the ground with the help of rhizomes and/or stolons (Fig. 2.4). Examples are bahiagrass, common bermudagrass, and subterranean clover. Rhizomes remain under the soil surface while stolons crawl on the surface. Both of these structures have nodes and internodes, and each node serves as a tillering/growth point; they also store food. When leaves and up-grown shoots are removed through grazing or manual harvest, new leaves and shoots emerge from the nodes utilizing the stored food. Because of this phenomenon, such species can tolerate close and continuous grazing. A few forages are the semi-erect type such as tall fescue (Fig. 2.5a), orchardgrass, and arrowleaf clover. These species have food storage structures, buds, and most of the leaves close to the ground, and are fairly tolerant of close grazing except under stress conditions. When leaves and stems are grazed or harvested, regrowth occurs from the buds situated at the stem bases utilizing the stored food. These species are intermediate between prostrate and erect species. Forages like switchgrass, coastal bermudagrass, sericea lespedeza, johnsongrass (Fig. 2.5b), and alfalfa grow upright. These forages have food reserves in stem bases and/or roots for regrowth and persistence. Continuous close grazing is not suitable for such species because continuous defoliation deplete food reserves and does not support vigorous plant regrowth. Rotational stocking with a rest period or continuous stocking at a rate low enough to leave higher stubble is required for managing these species.



Figure 2.4. Food storage sites of a few types of forages: (a) rhizome in bahiagrass, (b) crown in alfalfa – buds are emerging from the crown, (c) stolon in bermudagrass, (d) stolons of bermudagrass are creeping on the ground surface and shoots are growing from each node on the stolon.

Source: Adapted from Karki and Gurung, 2009.



Figure 2.5. Tall fescue (a), a semi-erect species with most of the leaves close to the ground and stems with inflorescence grown upright; Johnsongrass (b), an erect species with almost no leaves close to the ground.

Warm-Season and Cool-Season Species

Warm-season forages are originated under tropical and sub-tropical climates. These forages grow and mature in the warm portion of a year (late spring, summer, early fall), and die (annuals) or become dormant in winter (perennials). Bahiagrass, bermudagrass, switchgrass, bluestem, and sericea lespedeza are a few examples of warm-season forages. **Cool-season** forages are originated under temperate climates, grow in the cooler portion of a year (spring, fall, some portion of winter), and die (annuals) or become dormant during summer (perennials). A few examples of cool-season forages are oats, rye, ryegrass, tall fescue, and crimson clover. Optimum temperature range for warm-season forage species is about 85 to 95°F, whereas 60 to 80°F is ideal for cool-season species. However, individual legumes vary in terms of temperature with 65 to 75°F for clover, about 78°F for alfalfa, and 80 to 85°F for tropical legumes. Growth of warm-season grasses drops rapidly when temperature falls below 70°F, with virtually no production at 50°F.

Hands-on Activities

- 1. Display and give a presentation on plant parts of different forage species: roots, stems, leaves, flowers, stolons, rhizomes, legume root nodules, and seeds.
- 2. Forage identification: display samples and describe various forages grasses, legumes, forbs, shrubs, trees.

Key Points

- 1. Forage is any portion of plants, other than separated grain, that is eaten by animals to fulfill their nutrient requirements or harvested for animal feed.
- 2. Forages are classified in different ways depending on their growth pattern (prostrate, semi-erect, erect), longevity (annual, biennial, perennial), structure (legume, grass, forb), woodiness and size (herb, shrub, tree), and growth season (warm-season and cool-season).
- 3. Development of year-round pasture requires the incorporation of different classes of forages, and each class requires specific grazing management for persistence.

References

- Barnes, R. F., C. J. Nelson, and G. W. Fick. 2007. Terminology and classification of forage plants. In: R. F. Barnes, C. J. Nelson, K. J. Moore and M. Collins, editors, Forages: The science of grassland agriculture, No. II. Blackwell publishing, Ames, IA. p. 1-14.
- Karki, U. and N. K. Gurung. 2009. Year-round pasture production and management. Cooperative Extension Program, Tuskegee University, Publication No. TULV 0709-01 Livestock Production, p. 52.

CHAPTER 3 BASIC AGRONOMIC AND PHYSIOLOGICAL PRINCIPLES OF FORAGE PRODUCTION

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Introduction

Forage and forage-based livestock production enterprises are big business in the southern USA. Approximately 80 to 90 percent of all feed consumed in the Southern by livestock (beef cattle, dairy cattle, horses, goats, and sheep) is forage (Hevetter and Cuomo, 2001). The increase in fertilizer prices (Fig. 3.1) and the increase in commodity feed is moving more livestock producers to develop better management practices that will allow them to minimize inputs, but still produce high quality forage. The management of forages is challenging, but there is no need to make it overly complicated. Many livestock producers are moving to improve their nutrient management techniques, time of harvest, storage management and feeding management, and utilizing grazing techniques that will increase forage utilization and grazing efficiency. The combination of these types of management practices allows livestock producers to reduce costs and, in many cases, increase production. All these approaches have something in common to improve animal performance. The livestock industry is reverting back to a forage-based agriculture to mitigate cost. Thus, the longer we can keep animals out on pastures harvesting their own forage, the greater the opportunity to keep production costs down.



Figure 3.1. Average U.S. farm prices for selected fertilizers. Source: Fertilizer Use, Price, Economic Research Service, USDA. 2011.

Using Web Soil Survey to Determine Soil Types and Production Potential

The Web Soil Survey is one of the most useful tools a producer can utilize to find a land area that will allow determining the soil type(s) that is present in the farm and how forages will adapt to the existing soil conditions. The website is operated by the Department of Agriculture -Natural Resources Conservation Service (NRCS). Because forage yields depend in large part on soil properties, detailed knowledge of the soils on the farm/ranch can help producers in managing their enterprise more effectively. A soil survey provides detailed soil descriptions of the kinds of soil on the farm and the distinctive kind and amount of vegetation each soil can support (Fig. 3.2). Soil texture, depth, wetness, available water, slope, and topographic position are among the important soil properties that affect forage productivity. Utilizing this tool will allow forage and livestock producers to determine the tolerance of forage species to soil acidity. drainage conditions, and drought tolerance. Other important parameters that are useful to forage producers are soil texture (content of sand, silt and clay), depth to water table, erosion potential, and organic matter content. A soil survey also rates soil suitability for hay and pasture and identifies soils that are producing at less than their potential. This tool could be used in conjunction with a soil testing program to collect soil samples that are representative of the farm enterprise for long-term nutrient management plans.



Figure 3.2. Example of a soil survey map available from USDA NRCS' Web Soil Survey. Source: http://websoilsurvey.nrcs.usda.gov/app/HomePage.htm.

Soil Testing

Knowing the nutrient content and pH of your soil is the first step of working on a farm nutrient management program. Soil testing is a process by which specific nutrients (nitrogen, phosphorous, potassium, calcium, sodium, sulfur, manganese, copper, zinc, etc.) are measured for the availability to a specific forage crop. Determining the amount of these nutrients in the

soil will allow estimating the amount of fertilizer that is needed to satisfy the nutrient requirements of a specific forage crop. A soil test also measures soil pH, organic matter, exchangeable acidity and cation exchange capacity (Brady and Weil, 2000). Determining pH will producers whether lime is needed and, if so, how much to apply.

Taking a good soil sample is very important to gather all the necessary information. A soil sample should be taken at the right time and correct depth to satisfy the crop needs. A soil sample should be taken at least 3-6 months ahead of time in case the soil test report recommends lime; then there will be enough time to allow the lime to adjust the soil pH. Collecting a soil sample in perennial pastures is recommended every 2-3 years while in hay fields soil samples should be collected every year. The reason for a yearly soil sampling in hay field is because there are a large number of nutrients removed during hay production since that hay might be taken out of the farm or fed in other areas that where it is produced.



Figure 3.3. Schematic diagram of collecting soil samples from pastures. Map Source: Google Earth: http://www.google.com/earth/index.html.

A good soil testing program depends on how the sample is collected (Fig. 3.3). It is recommended to break large fields into 10 to 15 acre sections and collect 10 to 15 random core soil samples to a depth of 6 inches using a zigzag pattern across the field (Crouse and McCarty, 2006). Mix the soil cores and collect about one pint for analysis. When soil sampling, avoid lowland wet areas, feeding and watering areas, and areas close to fences or tree lines since livestock tend to concentrate urine and manure in these areas that could provide elevated nutrient

levels that are not representative of the entire area. Soil samples could be sent to the University or a private soil testing laboratory. Contact your local County Extension Office to obtain information sheets and soil sample boxes.

Ratings ¹	Description	
Very Low (VL)	Soil will yield less than 50% of its potential.	
	Large applications for soil building purposes	
	are usually recommended. Some of the	
	fertilizers should be placed in the drill for row	
	crops.	
Low (L)	Soil will yield 50 to 75% of its potential. Some	
	fertilizer should be placed in the drill for row	
	crops.	
Medium (M)	Soil will yield 75 to 100% of its potential.	
	Continued annual applications should be made	
	in this range. On some sandy soils that will not	
	retain much K, it may not be economical to	
	attempt to build beyond this medium level.	
High (H)	Supply of the nutrient is adequate for the crop,	
	and none is recommended for field and forage	
	crops. Where this recommendation is followed,	
	it is suggested that the area be sampled each	
	year.	
Very High (VH)	Supply of the nutrient is more than double the	
	amount considered adequate. Application of P	
	or K to soils of this rating is wasteful.	
Extremely High (EH)	Supply of the nutrient is more than four times	
	the amount considered adequate. The level is	
	excessive and further additions may be	
	detrimental to the crop and may contribute to	
	pollution of ground and surface waters.	

Table 3.1. General soil testing rating commonly used by soil testing laboratories.

¹The ratings are based on the relative yield that may be expected without adding the nutrient and when all other elements are in adequate supply. The nomenclature may vary among soil testing laboratories.

Source: Anonymous, 2000.

Most soil samples are processed and analyzed within a week, but it might take longer depending on the time and the number of soil samples submitted. When soil testing is complete a producer will receive an electronic report or a copy in the mail. The report will contain the index values from very low (VL) to very high (H+) for the nutrient requested as well as explanation of the technical terms along with fertilizer recommendations (Table 3.1). Consult your county agent for more help on interpreting soil test results and understanding how to implement them.



Figure 3.4. Relative availability of nutrients as a function of soil pH.

Nutrient Management

Lime Application and pH Adjustment

Soil pH has significant effects on nutrient availability and nutrient uptake by plants (Fig. 3.4). Most soils have a pH ranging from 5.2 to 5.8. Do not neglect the soil pH since it could affect soil tilth and root development and create nutrient imbalances. Low pH can affect fertilizer use efficiency and reduce N uptake by 30 to 35 percent, P by 45 to 50 percent and K by 10 to15 percent (Table 3.2). This translates into an economic loss of fertilizer dollars. However, many producers do not soil test and fertilize their soils regularly to avoid this expense.

Lime is a key ingredient to improving soil fertility. Lime is used to raise soil pH levels when the soil test reveals levels below optimal range. The optimal pH range varies between plant species (Table 3.3). Grasses usually have a higher tolerance to acidity compared to legumes. Limestone applications should be incorporated prior to seeding for best results. Since water is required for lime to react with the soil, effects of a lime application will be slower in a dry soil. It often takes six months to a year before a response can be measured even under perfect conditions. However, a response may be observed within weeks of the application when soil pH is extremely low. It is important to apply lime immediately after the growing season or crop removal to allow lime to react, correcting soil pH before the next growing season. Even though it is best to incorporate lime whenever possible, it is still important to surface-apply lime to correct the soil acidity

Chapter 3

problem in established pasture and hay fields. It has been documented that correcting pH in the top two to three inches of the soil has a positive effect on forage production (Jennings and Espinosa, 2006).

Soil pH	Nitrogen	Phosphorus	Potassium	
		Relative Nutrient Uptake (%)		
4.5	21	8	21	
5.0	38	10	30	
5.5	52	15	45	
6.0	63	15	60	
7.0	70	30	60	

Table 3.2. Effect of soil pH on relative efficiency of nutrient uptake.

Source: Stichler and Bade, 1998.

The reactivity time also depends on the type of lime used. Liming materials differ widely in their neutralizing powers due to variations in the percentage of calcium and/or magnesium. The coarseness of the liming material will also influence how fast the lime will react. In other words, the finer the liming material, the greater the surface area, resulting in faster reactivity, but not necessarily having a longer neutralizing effect. Generally, pelletized limestone sources are no more effective on weight basis than fine limestone. It is important to know the Relative Neutralizing Value (RNV) or Calcium Carbonate Equivalent (CCE) of different types of lime being used to adjust application rates. This is an index of how good lime is at neutralizing soil acidity. The RNV/CCE is calculated based on two quality parameters: purity and fineness (particle size) (Tisdale and Nelson, 2005). Keep in mind that lime quality is not indicated by how easy it is to transport, store, or spread. Table 3.4 provides RNV for different forms of lime.
Forage Type	Desired pH Range	
Legumes		
Alfalfa	6.2 - 7.5	
Arrowleaf clover	5.5 - 6.5	
Ball clover	5.0 - 8.0	
Berseem clover	5.8 - 7.0	
Crimson clover	5.0 - 6.5	
Ladino/white clover	5.5 - 6.5	
Lespedeza	5.5 - 7.0	
Red clover	5.8 - 6.8	
Vetch (hairy)	5.5 - 6.7	
Grasses		
Bermudagrass	5.0 - 7.5	
Bahiagrass	4.0 - 6.5	
Small grains		
Oats	5.0 - 7.0	
Rye	5.5 - 7.0	
Wheat	5.5 - 7.0	
Sorghum	5.8 - 7.0	
Sudangrass	5.5 - 7.0	
Tall fescue	5.5 - 7.0	

Table 3.3. Desired soil pH range for sustained growth of different forage crops.

Source: Griffin, 2004; Jennings and Espinosa, 2006.

Note: Low pH might limit root growth, plant persistence, yield and nutrient availability and uptake.

Table 3.4. Relative neutralizing value (RNV) of the pure forms of commonly used liming materials.

Lime		- DNV (0/) ¹
Common Name	Chemical Name	$= \mathbf{K} \mathbf{N} \mathbf{V} (70)$
Slag	Calcium silicate (CaSiO ₃)	86
Limestone	Calcium carbonate (CaCO ₃)	100
Dolomite	Calcium magnesium carbonate [CaMg(CO ₃)]	109
Slaked	Calcium hydroxide [Ca(OH) ₂]	135
Burned	Calcium oxide (CaO)	179

¹RNV represents the neutralizing value of the material compared to pure calcium carbonate. For example, dolomite lime neutralizes 9 percent more acid than the same weight of calcium carbonate.

Source: Peters et al., 1996.

Fertilization

Increasing fertilizer prices and the need for strategies that will maintain productivity is a major issue among livestock producers. Pasture fertilization should be carefully controlled by considering the individual goals of the producer. The following should be taken into consideration when developing a fertility program: 1) How much production is needed for the animals; 2) What time of the year is the forage needed most?; 3) What species are present?; and 4) What are my management strategies?. These questions will allow a producer to increase fertilizer efficiency and reduce cost.

Fertilizer Source	Nitrogen (N)	Phosphate (P ₂ O ₅)	Potash (K ₂ O)	Sulfur (S)	Effect on soil pH ¹
		% Nut	rient		
Nitrogen					
Ammonium nitrate	34				$\downarrow\downarrow$
Ammonium sulfate	21			24	$\downarrow\downarrow\downarrow\downarrow\downarrow$
Urea	46				$\downarrow\downarrow$
Urea ammonium nitratesolution	28 - 32				$\downarrow\downarrow$
Urea ammonium sulfate	33			18	$\downarrow \downarrow \downarrow \downarrow \downarrow \downarrow$
Phosphorous					
Diammonium phosphate (DAP)	18	46			$\downarrow\downarrow\downarrow\downarrow$
Monoammonium phosphate (MAP)					$\downarrow\downarrow\downarrow\downarrow\downarrow\downarrow$
Triple superphospate (TSP)		46		2	None
Potassium					
Potassium chloride			60		None
Potassium nitrate	13		44	4	Ļ
Potassium sulfate			48 - 52	18	$\downarrow\downarrow\downarrow\downarrow\downarrow\downarrow\downarrow$
Commercial Blends					
0-20-20		20	20		None
13-13-13	13	13	13		l.
17-17-17	17	17	17		Ļ
Poultry Litter ²	3	3	2		↑
Lime					
Calcitic Limestone					$\uparrow \uparrow \uparrow \uparrow \uparrow \uparrow$
Dolomitic Limestone					$\uparrow\uparrow\uparrow\uparrow\uparrow$

Table 3.5. Composition of most common chemical fertilizer materials used on forage production.

¹The direction of the arrows indicates increase (\uparrow) or decrease (\downarrow) in pH with the type of fertilizer applied. The number of arrows indicates the amount of changes on pH: \downarrow or \uparrow indicates slight change while $\uparrow\uparrow\uparrow\uparrow\uparrow$ or $\downarrow\downarrow\downarrow\downarrow\downarrow\downarrow\downarrow$ indicates substantial change in pH. The effect of these fertilizers

on soil pH will also depend on soil texture and the potential for fertilizer leaching, runoff, or volatilization.

²Assumes that poultry litter is 80 percent dry matter. Source: Ball et al., 2002; Hancock et al., 2011.

Hay fields and pastures should be treated differently in terms of when to apply fertilizers, especially nitrogen, even when soil test results are the same. To make hay, there is the need for good nutrition to maximize on productivity and quality of the final product. There are three major nutrients that have an impact on hay production and constitute a real cost to hay producers: Phosphorus (P), Potassium (K), and Nitrogen (N). The types of fertilizer sources could also affect soil acidity. Table 3.5 provides a detailed description on the effects of different fertilizer sources composition and their effect on soil pH.

Nitrogen (N)

Nitrogen is usually the most limiting element in hay production. Nitrogen is a major nutrient involved in chlorophyll development for photosynthetic activities, thereby affect biomass and quality of the forages. It is recommended to apply nitrogen when plants have reached 2 to 3 inches in height and have developed a root system that will increase nitrogen use efficiency and reduce leaching or runoff. Nitrogen, however, requires some timing and proper manipulations to get good yields and reduce losses. Bermudagrass hay production requires 150 to 200 lb N per acre. Splitting N applications will reduce the risk of leaching and volatilization losses as well as the risk for nitrate toxicity. The most efficient way to fertilize a hay field is to split-apply N based on the expected yield of the next growth. The actual rate should be 50 pounds N per ton of expected hay yield. Research has shown that splitting N applications can increase N use efficiency 25 to 35 percent and yields by 5 to 10 percent. Fertilizer should be applied at least thre days after cutting hay. Allowing the plants to recover and have some new green leaves will increase photosynthetic activity and will increase nutrient uptake. All the common N fertilizer products (ammonium nitrate, urea, urea ammonium sulfate, urea ammonium nitrate solution) work well. If urea or urea ammonium nitrate solution (UAN, 28-32%) are used, applying them right before rain will help to minimize N volatilization loss by incorporating them into the soil. Applications after a rain will increase losses due to higher evapotranspiration rates. Legumes properly inoculated before planting normally do not require nitrogen fertilization.

Phosphorus (P)

In the spring, phosphorus is a crucial nutrient in promoting the development of new roots and tillering. It is also a key element in plant cell membranes and all energy functions within the plant. Phosphorus could be applied to a hay field at any time of the year since it is very stable and available to the plant when needed. That is not the case when applying P to annual crops; it should be applied at planting (it should be incorporated). The flexibility on application times could benefit producers in obtaining P during the off-peak season when prices and application rates might be lower. If P levels are low, it could affect hay production and allow only 40 to 60 percent of the total hay production. The development of a good root system will allow extracting nutrients from restricted areas and increase nutrient uptake. Depending on the soil type, hay removes from 8 to 16 lbs of P per ton of hay produced per acre. Optimum levels of P can also increase the magnesium and calcium concentrations in leaves which enhance photosynthetic

activity. Nitrogen use efficiency could also be significantly increased by P fertilization. Optimal soil phosphorus level in your soil should be between 30 and 40 lb/acre. Legumes require higher levels of phosphorus than grasses.

Potassium (K)

Potassium is an essential nutrient for how plants respond in terms of drought tolerance, winter hardiness, disease resistance, and plant persistence. All enzymes or proteins in plants are dependent on K. It is involved in many metabolic processes in the plant. Potassium is involved with transport of N and other nutrients within plants. There is a very low environmental risk with K applications. The major inefficient use of K is a phenomenon called "luxury consumption." During this phenomenon, forage crops will take up more K than is required for optimum growth. To avoid luxury consumption, K should be applied on two or more split applications during the hay season or in pastures requiring more than 60 lb/ac/yr. A 60:40, 50:50 or 40:60 split K application could be ideal depending on the needs of the crop being grown. Potassium should be applied at the removal rate and based on soil test recommendations. Warm-season perennial crops could remove from 30 to 60 lb of K per ton of hay produced. Potassium in the soil remains relatively constant where forages are grazed and manure re-deposited on the field.

Poultry Litter Management

Manure such as poultry litter could also be an excellent choice for hay fields and pastures, especially with current high fertilizer prices if the producer could have access to it. Poultry litter can be used to fertilize all types of pastures and can be applied at any time of the year, but, like all fertilizers, it is best to apply near the time of crop uptake. This means in the spring for summer pastures and in the early fall for winter pastures. The best results are obtained from mixed pastures comprising grasses and legumes. In general, forage yields with poultry litter are comparable to those with commercial fertilizer, assuming the poultry litter is applied at an equivalent nitrogen rate (Table 3.6). Producers should use nutrient management planning and recommended rates to ensure poultry litter is used in ways that maximize its benefits without harming the environment and creating possible P loading issues. Keep in mind that the type of poultry litter used might affect the amount of available nutrients. There are many benefits when poultry litter is used wisely.

One of the disadvantages of poultry litter is that large quantities have to be applied in hay and pasture production to meet the species need (Table 3.7). Be aware that if manure is used as the sole source of N for a hay crop, excess phosphorus and potassium will likely be applied over time. It is important to know that only 50 percent of the nitrogen might be available the first year of application. Applying poultry litter between cuttings also provides other management strategies. This will reduce possible P runoff and K luxury consumption by the grass. This will also avoid storing and spreading the manure in the fall when manure nutrient use efficiency is generally low because grasses such as bermudagrass and bahiagrass are going dormant. This could also increase the economic return from nutrient utilization compared to late fall applications. Be careful not to apply too much manure; this will smother the hay and allow excessive moisture accumulation that could cause fungal diseases such as leaf spot disease. No more than 2 to 4 tons of manure per acre per year should be applied during the growing season. Apply as soon after harvest as practical to reduce potential injury to the regrowth. Spreading

litter onto a recently grazed or harvested pasture with 3 to 5 inches of stubble will help to hold the litter in place and reduce runoff. To further protect waterways, maintain a vegetated buffer 30 to 90 ft wide around all boundaries and next to any water sources. The width of the buffer will depend on slope, groundcover, and sensitivity of the waterway to pollution.

Tuble 3.0. The fulle full tent of unifierent types of poundy inter.				
Nutrients	Litter	Stockpiled	Cake	
		lb/ac		
Macro-				
Primary				
Nitrogen (N)	63	55	47	
Phosphate (P_2O_5)	55	57	59	
Potash (K_2O)	47	47	46	
Secondary				
Calcium (Ca)	43	36	54	
Magnesium (Mg)	9	10	81	
Sulfur (S)	15	12	91	
	npm ¹			
Micro-		r r		
Manganese (Mn)	334	362	340	
Copper (Cu)	319	313	366	
Zinc (Zn)	265	286	222	

Table 3.6. Average nutrient content of different types of poultry litter.

¹ppm = parts per million. Source: Gaskin et al., 2007.

Although most of the P in the litter is available, approximately 13 percent (range 6%–30%) of the phosphorus in poultry litter is in a water-soluble form, which means that it is immediately available for plant use. Using large quantities of poultry litter could also create a P loading issue if the soil test does not call for P applications. There is a disconnection between the nutrient ratios in the litter versus the nutrient ratio in forage uptake, especially for P. Most recommendations for litter use are based on the N requirements which results in an over application of P (Table 3.7). As a general rule, assume that about 90 percent of the P and K will be available the first year and the remainder will become available the following year. Test the poultry litter for nutrient content and follow regular soil testing (every year) to monitor for excess nutrients resulting from over fertilization with poultry litter.

Poultry litter could increase pH because of the amounts of calcium found in poultry feed. The type of poultry manure determines their effect on soil pH because poultry feed contains varying amounts of calcium carbonate. All poultry rations contain some ground limestone. Broiler feed may contain less than one percent ground limestone whereas layer and breeder rations may contain seven to ten percent ground limestone.

Forage	Utilization	Target N (lbs/ac)	Poultry Litter (tons/ac) ¹	Comments
Warm-season				
Hybrid bermudagrass	Pasture	100-150	4.2 - 5.3 (126- 159) ²	Application should be split with half applied in early spring and other half in midsummer.
	Hay	200-350		
	-		7.0 -12.2 (210-366)	Higher application rates will cause excess phosphorus accumulation in the soil.
Bahiagrass,				
Common Bermuda, or Dallisgrass	Pasture	75 - 120	2.6 – 4.2 (78 – 126)	Depending on grazing management, application may be split between early spring and summer.
Cool-season				
Fescue/Clover Mix (30 – 40% clover)	Pasture	50	1.8 (54)	Low N rates will benefit N fixation, P and K utilization.
Ryegrass, Small grains	Pasture	60 - 100	2.1- 4.2 (63-126)	The higher rate should be split between fall and late winter.

Table 3.7. Common poultry litter applications rates for different forages to meet nitrogen fertilizer requirements.

¹Based on average nitrogen content of 57 lbs/ton and only 50 percent available (28.5 lbs per ton). ²Pounds of P_2O_5 applied.

Sources: Gaskin et al., 2007; Chamblee and Todd, 2002.

The final question - is poultry litter right for your farm operation? That will depend on the price and your individual soil test results. If your soil is high in P and K, poultry litter will probably not be economical since you do not need those nutrients and they make up a large portion of the product (Tables 3.6 and 3.7). Most of the cost of poultry litter is in transportation and application. The closer you are to the source, the cheaper the product should be. A grower purchasing poultry litter should always request a poultry litter analysis to get an assurance of its nutrient content. In Mississippi when poultry litter is not tested, a good rule of thumb is to assume that the poultry litter is 80 percent dry matter and containing 3.56 percent N, 1.81 percent P_2O_5 , and 3.69 percent K_2O). The fertilizer grade is 3-2-3 (57-29-59 pounds of N-P₂O₅-K₂O per ton). The nutrients in poultry litter are in both mineral and organic forms. This means a proportion of the nitrogen, phosphorus, and potassium is immediately available to plants while the remainder (organic) must react in the soil to change into a form which is available for plant

use. However, nutrient availability of litter can vary 30 to 50 percent depending on the type of application method. If the poultry litter is incorporated, assume that 70 percent of the N is available, and 50 percent is available if poultry litter is broadcast.

Calculating Fertilizer Rates

The first step in applying the correct rate of fertilizer is calculating the forage crop nutrient requirements. A soil test is the only way to measure how much P_2O_5 and K_2O are available in soils, and soil tests are available through several private and public laboratories.

Chemical fertilizer is manufactured, mixed, and sold according to fertilizer grades. Fertilizer grade should not be confused with fertilizer rate. Fertilizer grade refers to the percent or pounds of plant food per 100 pounds of a fertilizer material. Fertilizer rate refers to the total amount of plant food nutrients (N, P_2O_5 , and K_2O) recommended per acre for a particular yield level of forage. Generally, there are three numbers in order that describe the concentrations of N- P_2O_5 -K₂O in the bag of fertilizer. For example, a fertilizer bag of diammonium phosphate (DAP) will have the numbers 18-46-0 on it, which means it contains a minimum of 18 percent N, 46 percent P_2O_5 , and no K₂O by weight. The N- P_2O_5 -K₂O numbers do not add up to 100 percent because fertilizers usually contain filler materials that help granule formation and assist with even product application. For liquid fertilizers, you need to know the density of the solution, as the nutrient concentration is based on the weight and not the volume. A common liquid fertilizer is urea ammonium nitrate; it contains 30 percent UAN that weighs 10.86 pounds per gallon and contains 30 percent N by weight.

In order to calculate a fertilizer application rate, four things are needed: (1) the N-P₂O₅-K₂O content of the material from the label, (2) the target rate (normally from a soil test), (3) the total area to be fertilized, and (4) the density of the material if a liquid fertilizer is to be used (Maguire et al., 2009).

Example 1: Liquid nitrogen fertilizer

Liquid urea ammonium nitrate (32%) is to be applied to 20 acres of hybrid bermudagrass. Calculate the N application rate in gallons per acre and the total tons of fertilizer needed to apply 60 lbs of N per acre to the 20 acres. The fertilizer weighs 11.26 lbs per gallon and contains 32% N by weight. The 32 percent UAN has 32 percent N by weight which means 0.32 lb N per pound of fertilizer.

Calculation

Lb N/gal of fertilizer solution = 11.26/gal x 0.32 lb N/lb of fertilizer = 3.60 lb N/gal. Gal of UAN/ac = 60 lb N/ac \div 3.60 lb N/gal = 16.7 gal/ac. Tons for 20 acres = $(16.7 \text{ gal/ac x } 20 \text{ acres x } 11.26 \text{ lb/gal}) \div 2000 \text{ lb/ton } = 1.9 \text{ tons.}$

Example 2: Dry granular fertilizer

Granular urea (46-0-0) and diammonium phosphate [DAP, (18-46-0)] is being used to supply 40 lbs of P and 50 lbs N per acre. Since DAP contains nitrogen, first calculate how much N is being supplied and reduce the urea application.

Calculation

Amount of DAP needed = 40 lb P/acre \div 0.46 = 87 lb of DAP/acre. Nitrogen supplied by DAP = 87 lb * 0.18 = 16 lb of N/acre. Amount of urea needed = (50 lb N - 16 lb N) \div 0.46 = 74 lbs of Urea/acre.

Fertilizer Application Methods

Established forages are usually fertilized by surface broadcasting of granular fertilizer. Fertilizers are only incorporated when establishing a new pasture or hay field or when rotating annual forage crops such as sorghums, annual ryegrass, and small grains. Nitrogen should be applied on split applications when the plant has developed enough green leaf area to optimize nutrient uptake and utilization. In a summer perennial hay system such as bermudagrass and bahiagrass, applications should be made after each cut. In a pasture system such as tall fescue or annual ryegrass, two applications, at the beginning of the growing season and after the first grazing period might be sufficient to sustain productivity if nutrients are being recycled uniformly by the livestock. Phosphate and potash can be land-applied (by broadcasting in existing pasture or by incorporating in a prepared seed bed) at any time, but normally it is more cost-effective to apply at the same time as N. Nitrogen is more mobile and should be applied as closely as possible to the time of crop uptake. Nitrogen in the form of nitrate can be lost from soils via leaching and can be denitrified to N gas in reducing conditions, such as soils saturated Ammonium (NH4⁺) forms of N are subject to losses through volatilization, with water. especially when surface-applied, especially during the warm summer months.

Cost Using Mixed Blends, Bulk Blends, and Poultry Litter

Forage producer have the tendency to select pre-packaged mixed blends like 13-13-13 or 17-17-17 because of their convenience but at the same time might be paying a higher price for a product that without a soil test might be over-applying some nutrients. The cost of fertilizer should be related to soil test recommendations. Bulk blended fertilizers have advantages over granulated fertilizers such as 13-13-13. Bulk blended fertilizers can be mixed using high analysis fertilizer materials, which allows the same amount of nutrients to be applied to a field with less weight and transportation costs. For example, 385 lbs/acre of 13-13-13 would be needed to apply a recommended rate of 50-50-50, but only 257 lbs/acre would be needed of a bulk blended fertilizer containing urea, DAP, and potash to apply the same amount of nutrients. The saving in time and transportation costs can be substantial when fertilizers are applied to large acreages. Bulk fertilizers also lower cost by reducing application of unnecessary nutrients.

When dealing with poultry litter, price of nutrients should be determined based on the nutrient analysis of the poultry litter and the necessary amount of nutrients to be applied based on soil test recommendations. Unless the litter is tested, assume about 57 pounds of N per ton is present in the poultry litter. The litter will be broadcasted, meaning that only 50 percent of those 57 lbs will be available. That means that out of the 57 lbs of N in the poultry litter, only 28.5 lbs of the N is available the growing season of application. Assuming N prices for ammonium nitrate at \$0.57 per pound (\$385 per ton), then a ton of poultry is worth \$32 per ton just for the N. Transportation costs vary with vendor, but expect to pay around \$2 per mile for a 20-ton truckload. Today poultry litter costs between \$50 and \$60 per ton. To illustrate this point, let's use the following scenario. A producer can buy poultry litter for \$50 a ton. No poultry analysis is provided

(assume 57 lbs N per ton of poultry litter) and it will be spread (50 percent available to plants = 28.5 lbs N). The producer has 20 acres of hay production and it calls for 200 lbs/ac of nitrogen, 40 lbs/ac of phosphate, and 60 lbs/ac of potash, according to soil test recommendations. Poultry litter will be applied based on N recommendations. This will require 84 tons of poultry litter to satisfy the N requirement (4.2 tons per acre). The cost per acre is \$257.10. The total cost for 20 acres will be \$4214.

On the other hand, if ammonium nitrate (34-0-0) is used, the total amount needed to meet the N requirement will be 352 lbs of ammonium nitrate per acre. The cost per acre will be \$67.94. The total cost will be \$1358.82. The difference between ammonium nitrate and poultry litter is very large. That means that the price has almost tripled, making the utilization of poultry litter not economically feasible in forage production. For a producer to obtain the price of commercial fertilizer for the growing season, poultry litter price has to be \$16 per ton. This does not account for the nutrients in the organic matter because they will not be available during that first growing season. Table 3.8 provides a good representation of a field application cost with different fertilizer sources.

Fertilizer Strategy	Price (\$/ton) ²	Lbs of Product/acre	Price (\$/acre)	
Blended Fertilizer ³				
13-13-13	\$385.00	462	\$88.94	
17-17-17	\$480.00	353	\$84.72	
Mixed Fertilizer				
Urea (46-0-0)	\$340.00	104	\$17.68	
DAP (18-46-0)	\$440.00	65	\$14.30	
Potash (0-0-60)	\$690.00	50	\$17.25	
Total		219	\$49.23	
Poultry Litter ⁴				
3-3-2	\$40.00	2500	\$50.00	

Table 3.8. Economic analysis of using different fertilizer combinations. It assumes a medium soil test level for P and K with a pH of 6.0 and a fertilization recommendation of 60-30-30.

¹NOTE: The fertilizer types and names mentioned in this publication are for management purposes only. No direct endorsement of these products is intended. Other products containing similar nutrient composition may provide similar levels of plant available nutrients based on soil test recommendations.

²Always check with your fertilizer dealer or local coop for up-to-date fertilizer prices.

³Applications are based on N requirements.

⁴Assumes 80 percent dry matter (DM) of the poultry litter. Keep in mind that approximately 50 percent of the total N will be available the first year of application. A nutrient analysis is recommended to determine proper nutrient distribution in the poultry litter.

Forage Nutrient Management

A forage system should be able to provide a dependable supply of quality feed to achieve the desired target goal of livestock performance. Nutrient application to forage crops is one of the few production practices that a producer can control. The major challenge is making sure that the required adjustment is made in specific nutrients by selecting the right rate, timing, and method of application.

		Nutrie	nt Uptake			
Forage Crop	Yield (ton/ac)	Ν	P_2O_5	K ₂ O	Mg	S
				lb ac ⁻¹ -		
Grasses						
Annual ryegrass	4.0	156	64	216		
Bahiagrass	7.0	300	85	240	35	25
Bermudagrass	8.0	370	95	340	25	45
Dallisgrass	2.0	68	28	88		
Sorghum/Sudangrass	5.0	185	70	235		
Tall fescue	3.5	135	65	185	15	20
Legumes ¹						
Alfalfa	8.0	480	110	480	40	40
Annual clovers	2.0	100	30	90		
Red clover	3.0	168	45	126		
White clover	6.0	380	90	280	30	30

Table 3.9 Nutr	uent removal fi	or selected (crons hase	on vield	notential
1 4010 5.7.1144	ione ronno vur re		crops buse	Ull ylulu	potentiai.

¹Legumes fix most of the nitrogen from the air.

Sources: Johnston and Mikkelsen, 2006; Usherwood, 1998.

Forage Nutrient Uptake and Demand

Forage crops can produce very high yields of digestible nutrients and can be a useful means of reducing overall feed costs. Achievement of high yield is an essential requirement to achieve low unit cost and depends upon paying attention to crop nutrition. In order to maintain forage production, especially on a hay production system, producers need to pay close attention to the amount of nutrients being removed in order to replenish those nutrients. Grass grown for hay removes large quantities of nitrogen, phosphorus, and other nutrients from soil (Table 3.9). Most of the time hay might be sold or fed on a different area of the farm; that means that the nutrients removed from a specific field are lost. Grass grown for pasture removes lower quantities of nutrients since as much as 85 to 90 percent of the nutrients consumed in the forage are redeposited on the pasture in the form of manure and urine. Due to the recycling effect of grazing animals, the nutrient requirements of pasture differ from the requirements of fields harvested for hay. On the other hand, legumes such as alfalfa and clover have the ability to take nitrogen from the atmosphere and convert it into a form usable by plants.

In a hay production system, large quantities of nutrients are removed based on yield and plant stage at the time of harvest. Warm-season grasses usually tend to remove higher quantities of nutrients. Most of these nutrients might leave the farm when hay is sold or when hay is fed in a different area. Table 3.9 provides general information of the total nutrient content of important forage cops in the southern U.S. Producers should apply nutrients to optimize both yield and quality. When economics play a role on nutrient applications, always fertilize the highly productive fields. Table 3.10 provides recommendation for fertilizing forage crops based on grass and legume distribution. Keep in mind that nutrient management for any forage crop is very site specific or field specific and that the crop nutrient requirement will vary depending on whether the forage is removed from the field as hay or livestock is allowed to graze the standing crop.

	Yield Potential of the Site (ton/ac)					
Plant Composition	1 – 2	2-4	4 – 6	6 – 8		
			- N (lb/ac)			
100% grass	50	75	100 - 150	150 - 200		
75% grass, 25% legume	25	50	75 – 100	100 - 150		
50% grass, 50% legume	0	25	50	75		
25% grass, 75% legume	0	0	25	50		

Table 3.10. Nutrient recommendations for high-rainfall grass and grass-legume pastures.

Source: Koenig et al., 2002.

Forage Establishment

Pasture establishment is vital to ensure high levels of production pastures. Before establishing new pastures or renovating existing pastures, producers must evaluate the farm's forage needs. It is important to consider how the forage will be used (grazing vs. hay), what species might be more adapted to the area, and what resources (equipment, money, and time) are available. Renovating a pasture should be based on existing percentages of the desirable species present in the pasture. The following criteria could be used in such a decision:

- 1. If the pasture contains 75 percent or more of the desirable species, then consider not renovating and concentrate on management.
- 2. If the pasture contains 40 to 75 percent of the desirable species, then consider over-seed and concentrate on management.
- 3. If the pasture contains less than 40 percent of the desirable species, then consider reestablishment.

New pasture establishment or renovating an existing pasture usually requires some management practices to get the forage growing quickly and vigorously. Some of the steps involved in

establishing or renovating a pasture include (a) soil testing and correcting soil nutrient deficiencies, (b) selecting species adapted to a specific area, (c) implementing the correct seeding method and rate, (d) implementing a weed control program, and (e) using proper management to maintain a productive stand.

Species Selection and Adaptation

The foundation of any good forage management program begins with establishing a good, vigorous stand of adapted grasses and legumes in the area. When establishing a forage crop, there are several points that a producer should consider and they include: (1) use adapted varieties or select the right species, (2) use a well-prepared seedbed, (3) plant at the correct time of the year, (4) select higher quality seed, (5) use proper seeding rate, (6) use proper planting depth, (7) provide adequate soil fertility and (8) properly manage the newly established pasture (Griffin, 2004; Meyer, 1999).

Variety Adaptation

Forage species or varieties selected will depend on the intended use (pasture vs. hay), area of adaptation, productivity potential, and the season of intended use. In some cases, there might be a mix of species that might have growth patterns and palatability. In some instances, a mixture of cool- and warm-season species might provide a longer grazing season. Selecting the right species or species mixture is extremely important. When establishing or renovating a pasture, it is important to match forage species to the site, soil type, and type of operation (grazing or hay, animal species and class). Know your soil types, soil composition, drainage, and forage capability. This information can be used to predict the success or failure of a potential forage species. Soil survey maps will provide this information.

Seasonal yield distribution is another factor to consider when making species selections. It is important to try and match the forage yield distribution with the animal's daily requirements. Cool-season perennial species (tall fescue) grow best between 60° and 80 °F, and they generally have their highest production in the spring, followed by a summer slump and another growth period in the fall (Hening et al., 1996a). Cool-season annuals (annual ryegrass and annual clovers) have some growth in the fall, followed by a period of dormancy or minimal growth in the winter and highest production in the spring. Warm-season annual (Sudangrass, millet, and sorghum) and perennial (bahiagrass, dallisgrass, and bermudagrass) species grow best between 80 and 95 °F (Henning et al., 1996a). Most warm-season grasses start their growth in April and will continue to grow until a hard freeze occurs in the fall. Peak production of warm-season grasses generally occurs during mid-summer. Legumes are also an important part of the establishment process because they can provide nitrogen to the grasses, as well as increase production during the spring months and increase pasture quality. Make sure that the growth habit of the selected legume species is compatible with the grass species because minimizing species competition is very crucial.

Seedbed Preparation

Good seed-to-soil contact is important to maintain adequate moisture around the seed for germination. If when walking across the prepared soil, the shoe heel sinks into the soil

completely, the seedbed is not optimum for planting. If the tracks of the person walking across the field are hardly visible, a good seedbed has been established.



Figure 3.5. Establishment of annual ryegrass using conventional tillage (left) vs. using a no-till in a bermudagrass pasture. Both pastures were planted the same day.

Conventional Tillage

A properly prepared seedbed is a key step in pasture establishment. Conventional tillage is beneficial when large soil clods and excess sod might impair seed germination. A fine and firm seedbed is prepared by disking followed by rolling the field with a cultipacker after the final disking. Forages established in a conventional seedbed usually establish quicker and more uniform than no-till established pastures. A firm seedbed may help ensure that seed is not planted too deep, which usually results in poor seedling emergence and weak pasture establishment. Conventional tillage seedbeds also warm quicker, allowing for better seed at cooler temperatures. Some disadvantages with conventional tillage include soil erosion potential, changes in soil structure due to tillage, and higher oxidation of organic matter (less moisture retention). A well prepared seed bed should be firm and shallow to allow the place of the seed at the proper depth. A good way to determine if a good seedbed has been prepared is by using the "rule of heel." If a person walks across the seedbed and sinks past the sole of the shoe more than ¹/₄-inch, the seedbed is too soft and should be cultipacked.

No-till Seedbed

No-tillage requires using herbicides to kill existing vegetation, mowing, or the practice of close grazing and then seeding directly into the residue. No-till seedbeds must also be prepared by reducing surface residue prior to seeding by hard grazing or hay removal (most are late summer for fall plantings). The advantages of no-tillage are the reduction of passes over the field, potential reduced soil erosion, and improved moisture conservation. The disadvantages of no-till are slower and less uniform seedling emergence.

Seeding Methods

Forage crops could be established using a variety of planters and planting techniques. The type of seeding method you choose will depend on the type of equipment available and whether planting on a no-till or a conventional seedbed. To ensure good soil-to-seed contact and that seed will germinate and emerge in a timely manner, different seeding methods are available. Some of these methods include drilling, cultipacking, and broadcasting. Drills and cultipacker seeders with some type of seed depth control are usually best for small seeded species.

Drilling

Drilling cuts a thin furrow in the soil, deposits the seed, then covers it and firms the soil with press wheels. A good rule is to plant the seed three to four times as deep as the diameter of the seed. Usually when drilling, stands are stronger and more vigorous but also seeding rates could be reduced by at least one-fourth.

Cultipacking

Most cultipackers consist of two sets of corrugated rollers with a seed box mounted on top of the frame directly between the two rollers. With a cultipack planter, the seed is dropped from a hopper onto the soil where toothed rollers press the seed below the surface. When using a cultipacker [the Brillion limits seed depth by the depth of the teeth; seeding depth can be adjusted by the firmness of the soil], be careful not to bury the seed too deep, decreasing germination.

Broadcasting

Broadcasting is the least desirable seeding method but probably is the most widely used. Broadcast seeding with a fertilizer spreader can result in an uneven seed distribution if the overlap is too wide. Less seed is distributed on the outer third so adjust your spacing to provide double coverage. Broadcasting followed by light disking is risky and can result in seed covered too deeply. Make sure the spreader is calibrated for the necessary seeding rate. When broadcasting, recommended seeding rates should be increased by 15 to 20 percent. Efficiency of a broadcast seeding can be greatly increased by rolling or cultipacking the seedbed before and after the seed is planted to establish a good soil-to-seed contact.

Grasses	Planting Date
Bahiagrass	April – October
Bermudagrass (common, hulled)	April – June
Bermudagrass (hybrid)	March – May
Browntop millet	June - August
Crabgrass	March – May
Dallisgrass	March – June
Foxtail millet	May – July
Pearl millet	April – June
Ryegrass, annual	September – October
Small grains ¹	September – October
Sorghum	May - June
Sudangrass	May – June
Tall fescue	August - October
Legumes	
Alfalfa	September - October
Alyceclover	May – June
Arrowleaf clover	September - November
Ball clover	September - October
Berseem clover	September - October
Cowpea	May – June
Crimson clover	August - October
Hairy vetch	September - October
Lespedeza, annual	February – March
Lespedeza, sericea	March – May
Red clover	October – November
White clover	October – November

Table 3.11. Planting dates for different forage crops in the southern U.S.

¹Small grains: Barley, Oats, Rye, Triticale, Wheat. Source: Ball et al., 2006.

Planting Time

Seeding on the correct date is also very important. The best planting times will vary by state and climatic zones within the state, especially soil moisture. Perennial grasses usually require 7 to 28 days for germination while legumes might require 7 to 14 days. Cool-season grasses (alfalfa, clover, tall fescue, annual ryegrass, and small grains) will be planted from September to November. Warm-season grasses (bahiagrass, bermudagrass, and dallisgrass) should be planted in late spring to early summer after the soil has reached a temperature of 65°F or above. Table 3.11 provides a relative range of planting dates for different southern forage crops. Usually spring seeding has plenty of moisture for seed germination, but there is an increase in weed pressure. Spring seeding should be made at least four weeks after the last frost killing. Late summer seeding is recommended for wet areas, since the soil is usually dry enough during the summer with less weed pressure. Fall seeding should be made at least four to six weeks before

the first killing frost in the fall; this will allow seed time to have adequate growth before winter. No-till-drill planting in late summer might provide adequate moisture for seed germination since organic matter provides cooler soil temperatures and higher moisture levels.

Select High Quality Seed

The success of pasture establishment or renovation will be only as good as the seed used. Selecting high-quality seeds can save time and money during forage production. To be able to understand seed quality, there is the need to understand the components usually involved in seed quality. Usually a good quality seed is a seed that has over 70 percent germination, seed is over 85 percent pure, contains less than one percent weed seed, contains very small amounts of restricted noxious weed, and contains no prohibited noxious weed seed. To determine this information, it is necessary to check the seed analysis tag found in the bag of purchased seed. If buying seed in small quantities for renovation purposes, it will be recommended to request the seed analysis information.

Forage seed quality depends on three key components: germination, purity, and hard seed (Spears and Green, 2001). Germination is the measure of how well a seed produces a normal, healthy seedling when planted under ideal conditions. The standard germination test, evaluated under the temperature considered ideal for each species, provides an estimation of seedling emergence if soil conditions at planting and during early seedling growth are near optimum. A germination test must have been made within at least six months of the date the seeds are sold. Purity is the total weight of seeds of the kind and variety stated on the tag (Fig. 3.6). If more than one kind or variety is named, the pure seed percentage of each component must be given. Hard seeds are viable seeds, but have a seed coat that is impermeable to water. Where hard seeds are present, total germination percentages are customarily determined by combining germination and hard seed percentages.

Good storage conditions are also essential for maintaining good seed quality High-quality forage seed can be stored successfully for more than one season if it is kept in a cool, dry environment. The shelf life of grass seed stored at room temperature (77°F) is roughly two years. Legume seed storage potential is fairly good; most can maintain germination for two years, with the exception of crimson clover, which can be stored only one year. Also, inoculated legumes might need to be re-inoculated since the inoculant usually expires after one year. Avoid storing seeds in metal storage buildings or attics. Temperatures there can be extremely high during the summer, and it does not take long under these conditions for germination potential to be destroyed. Basements are well suited for seed storage as long as moisture can be controlled. Forage seeds may be stored in freezers; however, freezing temperatures may kill the endophyte and rhizobia. Seeds are a tempting food source for rodents and many insects. To protect seeds from rodents, store them in metal trash cans (only in cool places) with the lid securely fixed. To control insects, tape no-pest strips on the inside of the lids. Do not insert the strip into the seed bag. Replace the strips every two to three months.



Figure 3.6. Information commonly found in a certified seed tag.

An inoculant (nitrogen fixing bacteria), should always be used when seeding legumes. The inoculant should be specific for the legume planted. Inoculants are live bacteria so they should be kept cool and moist until planting to get successful legume root nodulation and nitrogen fixation. Some legumes can be purchased with seed coat inoculants. In most cases though, the inoculant will need to be purchased separate from the seed and mixed with the seed just prior to planting. When purchasing inoculant, pay attention to the expiration date on the package, how the inoculants are stored, and the conditions of the package seal. Each package of inoculant is marked with an expiration date, and past that date the bacteria might likely be dead. Even if expiration date is still good, bacteria could be killed if stored at high temperatures. It is not recommended leaving the inoculant package in the dashboard or inside of a vehicle even for a short time. The best storage is in a refrigerator. Also, exposing inoculant or inoculated seeds to sunlight or ultraviolet light will kill the bacteria. Another precaution is making sure that the package is sealed correctly. Holes in the package may permit the peat and bacteria to dry and results in the death of the bacteria. Legume inoculants are divided into groups based on their capability of infection and N fixation for different legumes. Table 3.12 provides information on inoculation groups for commonly grown forage legumes.

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Table 5.12. Inoculation groups for commonly grown forage regulies.				
Inoculation Group	Legume Species	Inoculant Species		
Alfalfa	Alfalfa Black medic Burr clover (medic) Button clover (medic) Sweet clovers (yellow & white)	Rhizobium mellioti		
Bean	Beans	Rhizobium phaseoli		
Clover I	Berseem clover Crimson clover Lappa clover Persian clover Rose clover	<i>Rhizobium trifolli</i> strain		
Clover II	Rose clover Subterranean clover	Rhizobium trifolli strain		
Clover III	Alsike clover Ball clover Hop clover Ladino clover Red clover White clover	<i>Rhizobium trifolli</i> strain		
Clover IV	Arrowleaf clover (requires specific inoculum)	Rhizobium trifolli strain		
Soybean	Soybeans	<i>Bradyrhizobium japonicum</i> strain		
Cowpea	Alyce clover Aeschynomene Cowpeas Lespedeza	<i>Bradyrhizobium japonicum</i> strain		

Table 3.12. Inoculation groups for commonly grown forage legumes.

Source: Jennings, 2005.

The yield and quality of a pasture as well as animal performance on the forage can be influenced by the species and variety selected and by the quality of the seed purchased. Growers should read the seed tag carefully and purchase only those seed lots of adapted varieties that meet the standards known to promote a healthy, weed-free, high-quality pasture. Seed lots with even small amounts of weed seed or other crop seed can cause serious economic losses and diminish forage quality. Weeds and other crop plants compete with the desired species for nutrients, space, and soil moisture and are often difficult or expensive to control.

Seeding Rate and Planting Depth

Determining proper seeding rates depends on the species and seeding method being used. It is important to make sure that the seed used is good quality (germination rate and purity) and has not been stored for a long period of time. If the seed is poor quality, the seed must be applied at higher rates to obtain a desirable stand. If the seeding rate is too low, the stand will be thin and weedy. If it is too high, establishment costs will be prohibitive. If the seeding rate is ideal, stands can still fail by planting at improper depths or times. Table 3.13 provides broad ranges of seeding rates of selected forage crops in the southern USA in pure stand. Remember that these rates are only guidelines. They apply to typical pasture and hay operations, not to extreme conditions.

Forage Crop	Seeding Rate (lb/ac)	Seeding Depth (inches)	Seeding Vigor ¹
Grasses			
Bahiagrass	15 - 20	$\frac{1}{4} - \frac{1}{2}$	Р
Bermudagrass (common,	5 - 10	$0 - \frac{1}{2}$	G
hulled)			
Browntop millet	25 - 30	1/2 - 1	E
Crabgrass	8 – 12	¹ / ₄ - ¹ / ₂	G
Dallisgrass	10 -15 (PLS)	$\frac{1}{4} - \frac{1}{2}$	Р
Foxtail millet	20 - 30	$\frac{1}{4} - \frac{1}{2}$	E
Johnsongrass	20 - 30	1/2 - 1	G
Pearl millet	20 - 30	¹ / ₂ - 1	E
Ryegrass, annual	20 - 30	$\frac{1}{4} - \frac{1}{2}$	G
Small grains ²	90 - 120	1 – 2	G/E
Sorghum	15 - 20	1 – 2	G
Sudangrass	30 - 40	1/2 - 1	E
Tall fescue	15 - 20	1 – 2	Е
Legumes			
Alfalfa	15 - 20	$\frac{1}{4} - \frac{1}{2}$	G
Alyceclover	15 - 20	$\frac{1}{4} - \frac{1}{2}$	F
Arrowleaf clover	5 - 10	$\frac{1}{4} - \frac{1}{2}$	F
Ball clover	2 - 3	$0 - \frac{1}{4}$	F
Berseem clover	20 - 25	$\frac{1}{4} - \frac{1}{2}$	G
Cowpea	100 - 200	1 – 2	Е
Crimson clover	20 - 30	$\frac{1}{4} - \frac{1}{2}$	G
Hairy vetch	20 - 25	1 – 2	E
Lespedeza, annual	25 - 30	¹ / ₄ - ¹ / ₂	F
Lespedeza, sericea	12 – 15	¹ / ₄ - ¹ / ₂	Р
Red clover	12 – 15	¹ / ₄ - ¹ / ₂	E
White clover	2-3	$0 - \frac{1}{4}$	F

Table 3.13. Seeding rate and planting depth of selected forage crops in pure stands.

¹ Vigor, P = Poor, F = Fair, G = Good, E = Excellent.

²Small grains: Barley, Oats, Rye, Triticale, Wheat.

Source: Ball et al., 2006.

Seeding rates of forage crops will vary depending on the method of establishment. Using a drill will require less seed than broadcasting the seed. The higher rates are appropriate for average to poor soils and for broadcast seeding. Seeding rates should be calculated on pounds of pure live seed (PLS). This method assumes that every seed is viable and capable of producing an established plant. There are two components used to determine PLS: the germination percentage and the purity percentage. The seeding rate will also determine the number of seedlings per square foot. Twenty seedlings per square foot is a good target for a full productive stand. The use of certified seed with good quality is recommended. Buying low cost seed does not always translate into savings, since the seed quality may affect the amount of pure live seed necessary to achieve the desired seeding rate. The use of cheap seed with low quality is neither agronomical nor economically sound (Table 3.14).

Example:

PLS Index = (% Germination x % Purity) \div 10,000 PLS Index = (80 X 90) \div 10,000 = 0.72 Lb of Seed per acre = Recommended Seeding Rate \div PLS Index Lb of Seed per acre of bermudagrass = $10 \div 0.72 = 13.8$

Table 3.14. Determining the effect of low quality seed in planting rates and seed cos

	Planting rate (to give equivalent			
	Quality (purity x	Pure live	planting rate of live seeds)	Cost of live
Price \$/lb	germination)	seed (%)	(lb/ac)	seed (\$/lb)
3.00	(80 x 40)/100	32	4	12.00
	× ,			
2.50	(70 x 20)/100	14	10	25.00
	(
1.50	(60 x 10)/100	6	23	34.50
1	1			

¹Assumes that the same forage species is used with different seed quality.

If legumes are seeded, make sure the seed is inoculated with the proper bacterial strain. In many cases, legume seed has been pre-inoculated. If the seed is not pre-inoculated, mix prepackaged inoculum with the seed just prior to seeding. Make sure that the inoculants have been stored properly. Legumes form a symbiotic relationship with Rhizobium bacteria, in which nitrogen from the air is fixed into a plant-available form. There is no need for nitrogen fertilizer when legumes make up more than 30 percent of the pasture. It is vital to have proper seeding depth and seed coverage.

One of the major failures in forage establishment is placing the seed at the improper planting depth. Most seeds should be planted between one-fourth (1/4) to a half (1/2) inch deep. Large seeded crops such as small grains, sorghum, cowpeas, hairy vetch and tall fescue could be planted up to 2 inches in depth. When drilling legumes, make sure to plant no deeper than $\frac{1}{4}$ to $\frac{1}{2}$ inch depending on the seed type and size. Most clovers have very small seeds and it is usually recommended to broadcast the seed to avoid improper placement. Planting depths greater than 2 inches will decrease seedling emergence as much as 50 percent in some forage species. The exceptions are for vegetatively planted crops like hybrid bermudagrass. Small grains, peas, and eastern gamagrass could be planted at 1-2 inches depending on soil texture. Seeds planted on

clay, silt, or loam textured soils can be planted from $\frac{1}{4}$ to $\frac{1}{2}$ inch depth while sandy soils could be planted from $\frac{1}{2}$ to 1 inch depth. Table 3.13 provides a guideline to properly placing selected forage crops at the optimal depth.

Soil Fertility

Nutrient requirements for stand establishment are different than the fertility needs for maintaining productivity of established stands. Soil acidity is a major factor limiting forage production in the southern U.S. Acid soil conditions reduce nutrient availability, root growth, and nitrogen fixation by legumes. Cool-season grass pastures should be maintained at a pH of 6.0 to 6.2, while grass-legume mixtures should be kept at a pH of 6.2 to 6.4. Lime not only corrects soil acidity, but also supplies calcium and magnesium while reducing the availability of toxic nutrients such as aluminum and manganese. Lime should be applied six to twelve months before seeding to allow adequate time for it to react with the soil. Seeds can germinate without fertilization. However, once the small amount of nutrients in the seed is used, the young seedlings depend entirely on soil nutrients for their development. Phosphorus encourages root development. A well-developed root system helps protect seedlings from winter injury and produces vigorous stands the following spring. Table 3.15 provides general recommendations for phosphorus and potassium when establishing grass stands.

8		
Soil Test Rating	P_2O_5	K ₂ O
		lb ac ⁻¹
Very Low	30	100
Low	20	80
Medium	15	45
High	10	20
Very High	0	0

Table 3.15. Phosphorous and potassium recommendations for new grass seedling based on general soil test ratings.

Source: Meyer, 1999.

Growth of weeds may cause loss of new seedlings in spring plantings where companion crops are not used. Mow the weeds only if they offer severe competition to the new forage seedlings. Pure grass seedlings can be mowed short without much injury to the seedlings. Legume seedlings are injured severely by close mowing for weed control. Mowing for weed control should be done when daytime temperatures are cool. Weed control also may be obtained with the proper use of herbicides.

Forage Physiology

Growth and Development

The growth and development of forage plants have a major effect on how plants respond to harvest management and on forage quality. By understanding these effects, the forage manager can optimize the production and utilization of forages. Growth is the process by which a plant increases in the number and size of leaves and stems (Rayburn, 1993). Plant development on the

other hand is the process of a plant changing from one growth stage to another. This could be the development of tillers on a grass plant or flower buds on a legume plant. Usually plant development is the major factor affecting forage quality. Forage quality decreases as plants change from vegetative to reproductive stages. When in the reproductive stage, both grasses and legumes produce stemmy growth. As a plant matures, it increases in fiber and decreases in digestibility, crude protein and intake by livestock.

The result of plant growth is forage production and the amount harvested by animal or machine is forage yield. The growth of both plants and animals requires energy. Forages are a means of capturing free solar energy from the sun (photosynthesis) and incorporating natural resources of soil and rainfall to meet the nutritional needs of livestock. Photosynthesis is the process where the green pigment in the plant's leaf (chlorophyll) absorbs energy from sunlight and, using this energy, water, and carbon dioxide, produces oxygen and simple sugars. The plant then uses these sugars to make more complex sugars and starches for storage as energy reserves, to make cellulose and hemicellulose for cell walls, or with nitrogen to make proteins. How the plant uses its energy depends on the developmental stage of the plant and on environmental conditions. Understanding the growth and development of forage plants is helpful for maintaining a productive pasture stand, maximizing efficient use of water, nutrients, and light, and harvesting forage with high nutritive value by grazing or as stored forage.

Grasses

Grass pastures provide more total nutrients to cattle, sheep, goats, horses, and many other livestock in the southern U.S. than any other feedstuff. Cool-season grasses begin growth early in spring and often produce 70 to 80 percent of their herbage by late June. They are unproductive during the hot summer months unless irrigated. If moisture is available in fall, they will grow again until freezing. Warm-season grasses start growth about one month later in spring than cool-season grasses and grow slowly until soil temperatures exceed 65°F and air temperatures exceed 80°F. As a result, spring soil moisture is conserved and used from May to September when growth is most rapid. They become dormant in the winter.

The growth and development of grasses is usually divided in five primary growth stages (Waller, 1985; Moore et al., 1991).

- 1. **Germination:** this stage occurs after the seed is placed in the soil until the coleoptile (shoot) emerges from the soil.
- 2. **Vegetative:** the vegetative state begins with the emergence of the first leaf from the coleoptile. There could be many vegetative stages depending on the grass species and each successive sub-stage refers to the number of fully emerged and live leaves that are currently present.
- 3. **Elongation** as jointing. Each elongation sub-stage is defined by the number of nodes that are palpable or visible as a result of stem elongation. The elongation stage ends when the seed head is enclosed in the upper most leaf sheath. This is commonly known as the boot stage.
- 4. **Reproductive:** this stage begins with the emergence of the seed head and continues with seed formation. The rate and timing of reproductive development are determined by species, day length (photoperiod), and temperature.

5. **Seed ripening:** this stage pertains to the full development and maturation of the seed. This process will vary depending on the position of the seeds in the seed head. Upper seeds usually ripen before the seed in the lower part of the seed head.

Legumes

Legumes are second only to grasses in importance to livestock nutrition. Legumes are used in pure stands (monocultures) and in mixtures with grasses. Legumes may be harvested (mechanically or by grazing animals), left on the soil, or incorporated into the soil.

		Tolerance to ¹						
Clovers	Seeding Rate (lb/acre)	Seedling Vigor ¹	pH Range	Acidity	Poor Drainage	Drought	Grazing	Bloat Potential ²
Annual								
	5 - 10	F	6.0-6.5	F	Р	G	G	L
Arrowleaf								
Ball	2 - 3	Р	5.8-6.5	F	G	G	Е	L
Berseem	10 - 20	G	6.5-7.5	Р	Е	F	F	L
Crimson	20 - 30	Е	6.0-7.0	G	Р	F	F	М
Vetch	20 - 25	Е	5.0-8.0	G	Р	F	F	L
Perennial								
Red	8-15	E	6.0-6.5	F	F	G	G	L
White	2 - 3	F	6.0-7.0	F	G	F	E	М

Table 3.16. Characteristics of clovers commonly grown in Mississippi.

¹E=Excellent; G=Good; F=Fair; P=Poor

²L=Low; M=Medium; H=High.

Source: Ball et al., 2002.

The characteristics of clover species differ. Some are more tolerant of certain climatic conditions, soil conditions, and/or management regimes than others (Table 3.16). All clovers are not created equal and adding clovers to a winter annual or a perennial grazing system requires that the producer knows his soil and has addressed three major management challenges. The first challenge is to ensure that the pH has been adjusted well before planting. Sample soils at least six months ahead of the planting date and apply recommended lime so that fields will be ready for planting in the fall. Legumes need a higher pH (5.8 to 7) than grasses do, in part so the bacteria that fix the nitrogen can function effectively. Most clovers do poorly in acidic soils. Liming the soil to a pH of at least 5.8 will help ensure a good stand of clover. It is not recommended to attempt legume establishment until the soil pH is within the prescribed range for a specific variety. The second challenge is to ensure that the soil contains adequate levels of potassium and phosphorus for successful establishment and persistence.

Herbicide Name/Brand	Legumes (Alfalfa, clover)
2,4-D	3 weeks
Arsenal Powerline	12 months + bioassay
Cimarron	4 months
Cimarron Max @ 0.25 oz/ac plus 1 pt/ac	4 months
Cimarron Plus @ 0.25 oz/ac	4 months
Clarity/Banvel (per pint applied/acre)	120 days
Crossbow	3 weeks
Diuron	2 years
Forefront	bioassay ¹
Glyphosate	1 week
Grazon P + D	I year
Lineage Clearstand	12 months + bioassay
Milestone	bioassay
Outrider	12 months + bioassay
Overdrive	30 days
Paraquat	0 days
Pasturegard	1 month
Redeem R&P	bioassay
Remedy	3 weeks
Surmount	bioassay
Telar	bioassay
Velpar	2 years
Weedmaster	120 days

Table 3.17. Replanting restrictions of legumes based on herbicide applications.

¹Bioassay is a procedure for determining the concentration of the active ingredients of the herbicide still present in the soil. A soil sample needs to be collected and sent to the lab for analysis.

Note: The herbicide names or brands mentioned in this table are used as guidelines for establishing legumes. No direct endorsement of these products is intended. Other products providing similar weed control and approved for weed control in forage crops in Mississippi might be available. Contact your local County Extension Office for more information and pay close attention to application rates and hay and grazing restrictions.

Source: Anonymous, 2012.

DO NOT APPLY NITROGEN. Nitrogen will not kill legumes, but it stimulates grass growth, which will increase the competition with the legume and the likelihood of legume loss due to shading. If the clover composition in the pasture is less than 25 percent, then apply 30 to 40 pounds of N per acre. Application of about two pounds of boron per acre might also be necessary. The third challenge is to control broadleaf weeds before seeding clover in pastures. Once clovers are seeded in pastures, control of broadleaf weeds ranges from very difficult to impossible. Before planting clover, time your herbicide applications to achieve good weed control while still allowing an adequate period for residual activity to disappear. Keep in mind that the length of residual activity depends upon the herbicide used, the rate applied, and the weather conditions following applications. Check the herbicide label to determine appropriate

application rates and timing for various weeds. Table 3.17 provides a general description of the time line that a producer needs to follow to establish clover after an herbicide application.

The amount of nitrogen applied to pastures can be reduced or eliminated by planting clover or properly managing existing stands of clover in these pastures. There is a common misconception that nitrogen is released from the root of a growing clover plant and this nitrogen will supply the surrounding plants with nutrition. Research has shown that there is a small amount of nitrogen released or leaked from the nodules and roots of actively growing clover, but it is an insignificant amount and will not supplement the nitrogen requirement of the companion species. The primary method of nitrogen transfer from the clover to the soil is by decomposition of plant material. As clover plants mature and die, the nodules, roots, stems, and leaves are decomposed by soil microbes and nitrogen is slowly released to the soil. This slow release of nitrogen is beneficial to warm-season and cool-season grasses and will reduce or eliminate the need for nitrogen fertilization during this growing season.

Having 30 to 40 percent clover (based on a dry weight basis) in your pastures will help reduce your nitrogen needs. Clovers also favor profitability by lowering nitrogen fertilizer expense, which typically accounts for 20 to 50 percent of the cost of producing forage from grasses. Numerous studies have shown that annual clovers, ladino or white clover, and red clover often fix 60 to 150, 100 to 150, and 150 to 200 lb/ac/year, respectively (Table 3.18). At current nitrogen costs of around \$0.50/lb (ammonium nitrate), this represents a value of \$30 to over \$100 per acre per year. The value of nitrogen fixed by a clover stand in a single year is often several times as much as the cost of planting the clover. Clover seed usually costs \$10 to \$25 per acre. Many factors such as overgrazing, length of the growing season, soil type and the amount of nitrogen present in the soil will influence the amount of nitrogen that is fixed by clover from the atmosphere. Often the value of nitrogen fixed by clovers alone will more than offset the cost of their establishment. Other associated factors with establishing clovers depend on the site, situation, and method of seeding, but are typically less than the seed costs.

1 uole 5.10. 1 lulit (fiomy grown in sou	
Clovers	Cold Tolerance ¹	Maturity	N Replacement (lb/ac)
Annual			
Arrowleaf	G	Late	50 - 110
Ball	G	Medium	60 - 100
Berseem	Р	Late	90 - 110
Crimson	G	Early	70 - 125
Hairy Vetch	G	Late	50 - 150
Perennial			
Alfalfa	E	Late	150 - 200
Red	G	Late	75 - 200
White	G	Late	75 – 150

Table 3.18. Plant attributes of clovers commonly grown in southern U.S.

¹E=Excellent; G=Good; F=Fair; P=Poor

Source: Ball et al., 2002; Lacefield, 2002.

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Clovers	Bahia/Bermuda	Dallis	Johnsongrass	Tall Fescue ¹	Small Grain/Annual Ryegrass	
Annual						
Arrowleaf	\checkmark				\checkmark	
Ball	\checkmark				\checkmark	
Berseem	\checkmark	\checkmark	\checkmark		\checkmark	
Crimson	\checkmark				\checkmark	
Hairy vetch	\checkmark				\checkmark	
Perennial						
Red		\checkmark	\checkmark	\checkmark	\checkmark	
White	\checkmark	\checkmark		\checkmark	\checkmark	

Table 3.19. Compatibility of clovers with warm- and cool-season grasses for forage production.

¹Annual legumes such as arrowleaf, crimson, and hairy vetch may be grown with tall fescue but they are less desirable than perennial clovers. Source: Ball et al., 2002.

Table 3.19 provides a guide of clover/grass compatibility to help you properly choose the ideal species for your pastures. Research has shown that clovers improve animal gains and conception rates. High quality feed is important for a goat to gain well and for a goat to rebreed after kidding. Clovers are more digestible and contain more nutrients than grasses. Their presence in a pasture improves the palatability of the forage, which will increase the amount and quality of the forage the animal consumes. In a pasture situation when clovers are actively growing, most of the benefits come from increasing forage production and providing better forage quality since clovers have high percentages of crude protein (CP) and total digestible nutrients. A pasture that is composed of 70 percent grass and 30 percent clover will have 13 to 21 percent crude and as much as 60 percent total digestible nutrients during the vegetative stage.

Root Growth

Forages persistence depends on the development of a good root system. It is the pump to supply water, nutrients, and hormones to the upper part of the plant, but at the same time roots are the storage area for carbohydrates. On most forage species, it is desirable to provide some rest periods in grazing to permit root systems to rebuild their carbohydrate reserves for future growth. Producers do not usually think about the root system unless pasture growth is not good. They are the forgotten and unseen vital organs for plant growth and development. Roots also have a number of important functions: (1) anchoring the plant, (2) water absorption, (3) nutrient uptake, (5) storing carbohydrates, (5) absorbing and converting nitrates into organic acid and amino acids, and (6) producing hormones that are essential for growth in other parts of the plant.

The type of root system differs between grasses and legumes. Grasses have a fibrous root system which is heavily branched, especially in the upper soil horizons, making it well adapted for efficient uptake of nutrients and water. Warm-season grasses generally have roots that grow deeper into the soil than those of cool season grasses. The greater depth of rooting is important during periods of drought because it increases the volume of soil occupied by the root system and improves access to available soil water. Legumes differ in their type of root system.

Legumes such as alfalfa, sericea lespedeza, and kudzu have prominent taproots with fine branch roots, extending deep into the soil and accounting for the excellent drought tolerance of these perennial legumes. Red clover also has a tap root which gives it fairly good drought tolerance, but the primary root becomes infected with diseases and generally causes it to die after two years. In contrast, white or ladino clover has a taproot as a seedling but it dies after a year, leaving only fibrous roots which are at a shallow depth.

There are also other factors besides forage species that affect root development. They include root temperature, soil oxygen concentration, soil pH, and grazing management. Root growth in cool-season crops occurs when soil temperatures are 60 to 80 °F, while in warm-season grasses root growth occurs when soil temperatures are 80 to 90 °F. Soil oxygenation is usually affected by soil texture. A well-drained soil contains about 21 percent oxygen to a 6-inch depth (Hoveland, 1999). When soil oxygenation falls below 15 percent there is a decrease in nutrient absorption, below 12 percent new roots will not develop and below 10 percent the existing root tips cease growth. Thus, flooding or low soil oxygen causes more root damage at high temperatures. This problem is worse in clay than in sandy soils. Soil pH also has a major effect on root growth and development. At pH below 5.0, aluminum toxicity is harmful to root growth because it inhibits root development and root tips turn brown and branching stops. Aluminum toxicity also affects calcium and phosphorus uptake, therefore affecting cell division and respiration.



Figure 3.7. Effect of plant maturity in root sugar content and forage quality.

Note: Plants use stored sugars as they grow. Mature plants will regain vigor as they grow and store excess sugars in the roots or base of the plant. Grazing vegetative growth too soon (less than 8") before the plants have begun to restore the sugars reserves should be avoided.

Root growth is important to the competitive ability of plants, and understanding how herbage defoliation affects root growth has implications for development of management strategies. One of the most limiting factors to good root growth of perennial forage species is close, continuous grazing, especially during the first few months after planting. When leaves are removed from a grass or clover plant, new leaves develop and grow from buds on the crown or stems of the plant. This growth requires energy which comes from reserve carbohydrates (sugars and starches) or from actively photosynthesizing leaves remaining on the plant, but in most cases heavy grazing diminishes the amount of available leaf area. In most cases, carbohydrates need to be mobilized from the root system to help in the development of plant growth and other maintenance functions (Fig. 3.7). Continuous or close grazing will make roots more susceptible to drought and cold stress. Energy reserves increase in crowns during the latter part of the growing season and buds for next year's tillers develop. Consequently, severe defoliation near the end of the growing season will reduce the production of crown tissue and cause a decline in forage production the following year. A common grazing strategy is to "take half leave half." In other words remove half of the leaves or less in a grazing cycle and leave half of the leaves. This concept keeps the factory running and will cause minimal root growth stoppage to the plant. The livestock should not begin grazing until the forage has met the recommended forage height for the crop. The livestock need to be removed before the forage has reached the minimum forage height (3 inches) at end the grazing cycle. This process will maintain a good leaf area. The length of rest periods needed depends upon many factors, but the plant species and season of the year will greatly affect the time the plants need to rest.

Planning a Stockpiling Program

Winter feeding programs can contribute heavily to the overall ownership costs of a livestock production system. While the costs of some of the supplemental feed, fuel, and fertilizer are on the rise, stockpiling should be aimed at reducing feed costs. When properly implemented, it could reduce the hay feeding period by two months or more. One alternative to lower these costs is stockpiling forages. Stockpiling is defined as the accumulation of forage at one time of the year for grazing at a later time. Most producers are familiar with stockpiling tall fescue, but other warm-season perennial grasses such as bermudagrass and bahiagrass can also be used as part of the stockpiling program.

Grazing stockpiled forages is not a new concept. Stockpiling helps cut hay consumption and saves labor and time. Some producers usually comment that strip grazing is too labor intensive, but it only takes 30 minutes to move a fence that could provide two or three days of grazing. On the other hand, it takes about three hours to feed hay every day and about seven hours per acre to produce that hay during the summer. These changes in winter feeding/grazing programs can substantially reduce winter feeding costs.

Stockpiling Cool-season Grasses

Tall fescue is the most desirable grass to stockpile for late fall and early winter grazing. It allows producers to extend the grazing season well beyond the growing season, reducing the demand of inputs such as hay, silage, and dehydrated forages. Under proper grazing of stockpiled tall fescue, grazing animals distribute their manure evenly over the pasture, returning nutrients to the soil.

Two components to consider when stockpiling tall fescue are forage quality and yield. Important management factors affecting the balance between yield and quality of stockpiled fescue are: when to begin stockpiling (last day of grazing or mowing), nitrogen application (date and rate), and the legume composition in the pasture. Stockpiling tall fescue should start from late August to late September. Prior to stockpiling, fields should be mowed or grazed closely and livestock removed from the pasture. Tall fescue is also very responsive to nitrogen fertilizer and high yields can be achieved with timely N application (Fig. 3.8). Before applying fertilizers, a soil test should be taken to determine the phosphorus, potassium, and liming requirements. Nitrogen may be top-dressed approximately 60-70 days before the end of the growing season at the rate of 40 to 60 lb N/ac along with P_2O_5 and K_2O as indicated by soil test. Applying nitrogen too early may encourage the growth of late summer emerging weeds and subsequently reduce the production of tall fescue. Applying nitrogen too late will reduce the quantity of forage which is stockpiled. Early, mid-, and late September is optimum time to apply nitrogen to tall fescue. Take into consideration that these management practices may need to be adjusted, depending on the type of livestock operation and location.



Figure 3.8. Influence of nitrogen fertilization on yield and protein of stockpiled tall fescue. Source: Johnson and Smith, 2004.

Stockpiling Warm-season Grasses

Stockpiled warm-season grasses (bermudagrass or bahiagrass) can provide the required nutrition for dry mature cows and spring-calving cows (with good body condition) late in the fall if properly managed until overseeded annual ryegrass can provide necessary nutrition throughout the remainder of the winter feeding period.

Warm-season perennial grasses (WSG) such as bermudagrass and bahiagrass could provide grazing from late October to early January. Availability of stockpiled warm-season forages is much shorter than tall fescue (late November or early December to late February) because of faster dry matter deterioration with WSG. Stockpiling works well with bermudagrass or bahiagrass as monocultures or mixed with most legumes. Clovers (white or red) are good choices for stockpiling. This could help to fill the gap until some of the annual cool-season grasses such as annual ryegrass and small grains are available for grazing. A three-year study (2003-06) conducted in Arkansas indicated that stockpiling bermudagrass can provide an average savings of \$20.14 per animal unit when compared to feeding hay (Jennings et al., 2012). Although most perennial warm-season grasses are good for stockpiling, quality will be lower than with cool-season species such as tall fescue.

Stockpiling involves much more than just excluding livestock from the pasture for a few weeks before the winter starts; it requires management. Graze pastures to a three-inch stubble height or harvest the final cutting of hay approximately eight weeks prior to the first estimated frost (Dietz, 1989). Mowing the existing biomass is used as the last resort, but it is not recommended because it places a thatch on top of the grass which delays new growth. Stockpiling warm-season grasses should start mid-August to early September provided that there is adequate moisture and the appropriate fertility program. This will give grasses the opportunity to grow for two months before going dormant in mid- to late October. Nitrogen application should be between 50 and 70 lbs of N per acre when stockpiling pure or mixed warm-season grasses (no legumes present) to produce the required forage quantity and nutritive value. Phosphorous and potassium should be applied based on soil test recommendations.

In order for stockpiled bermudagrass and bahiagrass to contribute to the program, make sure that the stocking rate is balanced and that some pastures could be deferred for stockpiling and overseeding annual ryegrass without affecting grazing/feeding patterns. In case of inadequate moisture, to produce the desired forage quantity of stockpiled warm season grasses, make sure that a reserve of good quality hay is available to sustain the herd until ryegrass is available (if other cool season grasses such as tall fescue are not a feasible alternative). With proper fertilization and depending on climatic conditions, 2000 to 3000 lbs of dry matter (DM) per acre could be stockpiled by November. That means that a mature goat (60 lbs) with a 4 percent of the body weight requirement will need 2.4 lbs of DM per day. If a producer is planning to utilize 65 percent of the stockpiled forage for 90 days to maintain a herd of 100 goats, 21,600 lbs DM are required by the animals. At a 2000 lb DM per acre production, 16.6 acres are required for stockpiling to graze 100 goats from November through the end of January with minimal hay required (6 goats/acre).

Biomass Accumulation	Yield	Crude Protein	ADF	
(Nov. – Feb.)				
	lb/ac	%		
Bahiagrass				
Tifton 9	588.5	13.6	35.8	
Pensacola	458.1	13.9	35.0	
Bermudagrass				
Coastal	666.2	11.6	33.0	
Common	725.1		34.1	
Cheyenne	761.7	14.0	32.4	
Giant	714.4		38.2	
Tifton 85	1068.9	12.5	37.4	
Wrangler	513.5		30.7	

Table 3.20. Biomass production and forage quality of warm-season perennial grasses from November to February.

Source: Evers et al., 2004.

Stockpiling of warm-season perennials in the autumn depends on forage variety (Table 3.20), precipitation, temperature, nitrogen fertilization, and duration of the stockpiling period. Studies have suggested that forage quality is maintained through late autumn (Evers et al., 2004; Scarbrough et al., 2001). Crude protein (CP) remains relatively stable while neutral detergent fiber (NDF) and acid detergent fiber (ADF) increase slightly (Table 3.20). One of the most significant increases is lignin concentration. Most stockpiled warm-season perennial grasses should provide eight to fourteen percent CP and more than 50 percent total digestible nutrients through January (Fig. 3.9). Dry matter digestibility during fall and winter is highly dependent on the stage of maturity when dormancy occurs. Leaves of bermudagrass or bahiagrass are not as tolerant to freezing damage as tall fescue so the amount of leaf material and palatability declines steadily after the onset of freezing weather. There is the possibility that appropriate supplementation will likely be required.





Figure 3.9. Changes on crude protein (CP) and acid detergent fiber in warm-season perennial grasses (bermudagrass and bahiagrass) from October to February. Source: Evers et al., 2004.

Management of Stockpiled Forages

Grazing management is critical to efficient utilization of the forage. Uncontrolled grazing will waste approximately 50 to 60 percent of the forage due to trampling and manure deposition on unutilized forage (Rayburn, 2003). Restricting access to a three- or seven-day forage supply will increase the number of grazing days. Install a temporary electric fence across the field dividing it so the area to be grazed first has a source of water and minerals. Once the animals have grazed this area off, move the fence back, opening up a new strip. Repeat this system until the entire field has been grazed.

Due to the fact that tall fescue holds its quality, producers should graze any crop residues (corn, soybean, cotton, or milo) that might be available first in the fall and use tall fescue later in the winter. If there is a difference in length of stockpiling period among pastures, begin grazing the oldest material first before it becomes too deteriorated. If some areas have a significant amount of red clover, graze them early as well because red clover deteriorates more rapidly than tall fescue.

Strip grazing is the recommended method to obtain a better return from stockpiled forages. If grazing is not controlled, much forage will be wasted because goats will select the leafy material the first four to six weeks. The goal is to efficiently harvest the forage by manipulating access so that they will graze down only the top two-third of the grass which is primarily leaf. Leave the bottom one-third of the grass, which is mostly low-quality stem, to protect the pasture against winter freeze and help control erosion. Use a single-strand electric fence to partition the available forage in the paddocks and graze for a two to three day period, allowing the goats to harvest 65 percent of the standing forage. Always begin grazing the area close to water to avoid wasting

forage due to animal trampling. It is important that free choice minerals are supplemented during the grazing period and body condition is closely monitored. Observe the manure consistency in the animals to determine if protein deficiency might be an issue. In this case, resume the traditional hay feeding program, add protein and/or energy supplements if the average body condition starts to decline, or initiate grazing ryegrass if ready to be grazed. Gains will generally be considerably better in November and early December rather than later in the season. The extent of deterioration of the accumulated warm-season grasses growth will also affect animal gains.

Forage Quality and Testing

Many livestock species use forages as their primary source of nutrition. Forage testing assesses the nutrient composition of forages, which allows ranchers to develop feeding programs and commercial hay producers to develop marketing strategies. Forage quality is defined as the forage's potential to meet the nutritional needs of a particular animal. It involves consumption, nutrition value, and the resulting animal performance (Hall, 1994). Hay quality includes palatability, digestibility, intake, nutrient content, and anti-quality factors. The primary reason for livestock producers to test their hay is to increase their net profit. Not knowing the forage's nutrient composition might create situations in which the producer might under- or over-estimate nutrient requirements and cut profitability.

Factors Affecting Forage Quality

Six major factors affecting forage quality (not yield), ranked by their impact on forage quality, include: 1) maturity, 2) crop species, 3) harvest and storage, 4) season, 5) soil fertility, and 6) variety (Ball et al., 1997; Adesogan et. al, 2009). The relative importance of each of these factors, along with some exceptions to the ranking, is described below.

1. **Maturity (harvest date).** Maturity is the most important factor affecting forage quality. Plants continually change in forage quality as they mature (Table 3.21). As plant cell wall content increases, indigestible lignin accumulates. Forage plant maturity changes so rapidly that it is possible to measure significant declines in forage quality every two or three days. For example, bermudagrass that is harvested after four weeks can lose up to five percent crude protein per day from when delayed from a typical cutting schedule (four to five weeks).

		Quality	
Forage Group	Leaves	СР	NDF
		- % DM	
Grasses			
Vegetative	>50	>18	<55
Boot	40 - 50	13 – 18	55 - 60
Head	30 - 40	8-12	61 - 65
Mature	20 - 30	<8	>65
Legumes			
Vegetative	40 - 50	>19	<40
Bud	35 - 45	17 – 19	40 - 46
Early flower	25 - 40	13 – 16	47 – 51
Late flower	<30	<13	>51

Table 3.21. Changes in botanical composition and forage quality of forage groups at different maturity stages.

Source: Schroeder, 1996.

- 2. **Crop species.** Differences in forage quality between grasses and legumes can be very large. The protein content of legumes is typically much higher than that of grasses (Table 3.22), and legume fiber tends to be digested faster than grass fiber, allowing the ruminant to eat more of the legume.
- 3. **Harvest and storage:** Improper harvest techniques can seriously reduce forage quality, primarily through the loss of leaves. Storing a hay crop at an incorrect moisture content, or improper ensiling of a forage crop, can dramatically lower its quality. Storing hay outside will also increase hay loses up to 50 percent if left outside.
- 4. **Season:** Moisture, temperature, and the amount of sunlight influence forage quality. Rain damage is very destructive to forage quality. When bad weather delays harvesting, the forage crop becomes more mature and hence lower in quality. High temperatures may increase lignin accumulation and decrease quality, but drought stress may actually benefit quality by delaying maturity and allowing higher concentration of nutrients in the stressed plants.
- 5. Soil fertility. Soil fertility affects forage yield much more than it does quality. While it is possible to produce high quality forage on poor, unproductive soils, it is generally very difficult to produce high yields of high quality forage with an unproductive soil resource. Proper soil phosphorus (P) and potassium (K) levels help to keep desirable legumes in a mixed seeding and also reduce weed problems. It is necessary to balance soil fertility to avoid mineral imbalances in ruminants. Low soil fertility, as well as very high fertility, has resulted in reduced forage quality.

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Crop	CP ²	ADF ²	NDF ²	TDN ²	RFV ²
Alfalfa	22 - 26	28 - 32	38 - 47	64 – 71	90 - 127
Grass	10 - 18	35 - 48	45 - 65	49 - 62	60 - 111
Grass / Legume mix	9-17	32 - 47	42 - 58	56 - 62	80 - 105
Small grains ³	8-16	35 - 46	48 - 67	55 - 64	95 – 120
Ryegrass	12 – 16	27 - 33	47 – 53	63 – 68	111 – 134
Corn	7 - 10	24 - 32	48 - 60	64 - 71	105 - 138
Silage					
Bermudagrass	7 – 16	33 - 38	55 - 68	38 - 54	81 – 93
Bahiagrass	4 - 13	34 - 50	49 - 61	42 - 56	75 - 92
Dallisgrass	5 - 10	38 - 54	55 - 70	38 - 51	65 - 88
Tall	12 – 16	30 - 36	50 - 56	61 - 66	101 - 122
fescue/Orchardgrass	12 10	50 50	20 20	01 00	101 122
Red clover	14 - 16	28 - 32	38 - 42	64 - 67	142 - 164
White clover	18 - 25	24 - 38	30 - 44	55 - 70	115 - 150
Warm-season annual grasses ⁴	8 -12	35-40	55 - 70	50 - 58	77 - 104
Switchgrass	10 - 14	35 - 40	55 - 60	58 - 62	90 - 104
Crabgrass	12 - 18	32 - 36	43 - 58	59 - 68	80 - 110
Annual lespedeza	12 – 16	35 - 40	45 - 55	58 - 62	98 - 127
Eastern gamagrass	12 - 20	29 - 40	42 - 61	50 - 57	80 - 95

Table 3.22 Forage quality¹ parameters for different forage crops

¹Forage quality based on cutting at boot stage (grasses) or bud stage (legumes).

²Abreviatons over columns are: CP = Crude Protein; ADF = Acid Detergent Fiber; NDF =Neutral Detergent Fiber; TDN = Total Digestible Nutrients; RFV = Relative Feed Value. ³Small grains: wheat, oats, rye.

⁴Warm-season annual grasses: pearl millet, sorghum, sorghum-Sudangrass.

- Source: Ball et al., 2002; Beck et al., 2007.
 - 6. Variety (cultivar). After decades of breeding forages for yield and persistence, attention has recently been focused on developing or identifying varieties with improved quality. Variety or cultivar can affect forage quality, but not as greatly as the other five factors. In alfalfa, selection for improved quality is underway by most commercial companies, and several U.S. firms have initiated selection in corn silage hybrids for improved forage quality.

Forage Analysis

Since hay and other stored forages play a major role in winter-feeding programs, testing hay now will provide producers with adequate time to design a good feeding program that will improve hay utilization and optimize livestock performance. Forage testing will provide more accurate information about the forage nutritive value and how to adjust the amount of protein and energy supplements necessary to meet animal requirements.

Forage testing and comparing the reported protein and digestibility to the needs of the livestock is a good way to evaluate the merits of improving forage quality. An integrated method of evaluating forage quantity and quality is to use a "weak-link analysis" to evaluate the management balance across the forage-livestock system. This method allows determining how to invest resources to get the greatest "bang-for-the-buck."

Collecting a Hay Sample

Producers should routinely get a representative sample for hay analysis because forage quality can change based on forage species and mixtures, maturity, management, harvest and storage conditions, rain damage, and insect or disease damage. When sampling different hay lots, sample each hay lot separately (Adjei et al., 2006; Marsalis et al., 2009). A hay lot is defined as hay from the same field, same cutting, harvested under the same environmental conditions, and having a uniform forage composition (grass or legume only, or grass/legume mixture).

To accurately determine the quality of the hay, a representative sample must be taken using a hay probe (Table 3.23). Use a hay probe that is 12 to 24 inches long and three-eighth (3/8) to fiveeighth (5/8) inches in diameter (Martin et al., 1988; Owens and Thiex, 2002). Grabbing and pulling hay from different bales is not the correct method, and it will not provide uniform samples for analysis. Producers should sample 15 to 20 round bales depending on the number of bales in the lot, and samples should be taken from the round edge of the bale (Barnhart, 2004). For example, if sampling a hay lot that contains 300 bales, sample every 15th bale to obtain a representative sample of the entire lot. If the outer layer of the bale has deteriorated, remove that layer before sampling to avoid collecting material that will skew the analysis.

		•	
Type of bale	Leaf and stem distribution	Best place to Sample	
	Leaves are concentrated in the	Take a core sample through	
Small squares	tight end of the bale.	the center and the butt end of	
		the bale.	
	Leaf and stem are uniform	Take a sample at a 45° angle	
Large squares	across the butt face, but may	on the side or at a 90° angle at	
	vary along the length.	the end of the bale.	
		Take a sample on the curved	
Round	Uniform distribution along the	side of the bale. Remove the	
	circumference.	outer layer if is moldy	
		conditions exist.	

Table 3.23. Sampling recommendations for different types of hay.

Source: Undersander et al., 2005.

Sample at least 10 square bales near the center of their ends to ensure a uniform distribution of leaves and stems in the sample. If square bales have been stacked in an open barn, collect samples in both sides of the barn in a zigzag pattern or at different heights. Once the samples are obtained from each lot, mix the samples thoroughly in a bucket and store in a quart-size, plastic zip-lock bag. Hay samples are perishable, so it is important to ship or deliver the samples to the lab as soon as possible to prevent moisture loss and microbial deterioration of the sample. Label the bag with all the necessary information using a permanent marker (producer's name, hay lot, forage species, hay cutting, weather conditions, etc). Sometimes information written on a plastic
zip-lock bag can be erased, so make sure that a label with the same information is placed inside the bag as a preventive measure and for easy identification. Fill out the information sheet provided by the forage testing lab. If producers are working with Extension agents and livestock or forage Extension specialists, some laboratories will send copies of the report to them as well, so make sure their names and addresses are in the appropriate places on the form.

For pastures that will be grazed, samples are obtained directly from the standing forage in the field. These samples should be taken shortly before the livestock are turned into a pasture. The producers should walk over the entire field and collect 30 to 50 random small grab samples per each five acres. Grab samples are taken by reaching down and grabbing a small section of forage between the thumb and forefinger and at the same height that the livestock will graze the pasture. Avoid collecting samples in areas that have high weed infestation or areas that have high concentrations of legumes or grass.

Depending on where the samples are sent for analysis, time of the year, and the location of the forage lab, results can take up to three weeks. The cost for analysis of CP, ADF, and NDF ranges from about \$15 to \$50, depending on the labs. Once the results come back, use them to balance the forage-feeding program for the various groups of livestock on your farm.

Hay utilization by livestock can be improved by knowing the nutrient composition of the hay-especially crude protein, fiber, and total energy (Table 3.24 and Table 3.25). The accuracy of forage analysis depends on the sample that you send to the lab. In many feeding programs, not knowing the forage content of the hay is the weakest link. The results of the lab tests will be useful only if the sample accurately represents what your animals will be eating. The forage analysis information could decrease feed cost per animal, while maintaining or increasing production. Poor sampling will result in misleading values, higher feed costs, and reduced performance. Keep in mind that every field and every cutting will be different. Increasing profitability per animal will depend on forage quality and utilization. The results of forage tests may be compared to the requirements for total digestible nutrients (TDN) and protein of different classes of livestock. If you do not know how to use the results, contact your County Extension Office or livestock/forage specialists for guidance. It is important to balance hay nutrient composition from test results when possible with proper minerals and vitamins or appropriate additives to provide adequate supplementation to the livestock.

	Нау Туре	2				
	Grass		Legume		Silage ¹	
Quality	TDN^2	СР	TDN^2	СР	TDN^2	СР
		Perce	nt (Dry Ma	tter Basis)		
Excellent	>58	>12	>64	>18	>65	>8
Good	55 - 57	10 - 11	60 - 63	16 – 17	60 - 64	7 - 8
Fair	52 - 54	8 – 9	57 – 59	14 – 15	55 - 59	6 – 7
Poor	<52	<8	<57	<14	<55	<6

Table 3.24. Forage quality standards for hay production.

¹Silage values are based on different moisture levels. Excellent (<70%), Good (71 - 74%), Fair (75 - 79%) and Poor (>80%).

²Determine hay quality by TDN rating. If hay does not meet CP requirements or is less than 83 percent dry matter, or if silage does not meet either CP or moisture requirement for quality, lower one grade.

Source: Lemus, 2009.

Interpreting Forage Test Results

Knowing information about forage quality will allow balancing rations, reducing costs and improving overall nutritional plan. Feedback from the forage analysis could improve future crop management if present forage is of poor quality, and could also determine prices for feed and supplements based on nutritive value. Forage quality analysis information varies from laboratory to laboratory, but usually contains information related to moisture (%), dry matter (DM, %), crude protein (CP, %), acid detergent fiber (ADF, %), neutral detergent fiber (NDF, %), total digestible nutrients (TDN, %), net energy calculations for lactation (NE_L, mcal/lb), maintenance (NE_M, mcal/lb), and gain (NE_G, mcal/lb), and relative feed value (RFV) (Henning et al., 1996b).

Dry matter usually refers to the amount of forage that is not water. Acid detergent fiber is a measure of the least digestible plant carbohydrate (cellulose and lignin). Acid detergent fiber is negatively correlated with digestibility, and consequently is often used to estimate energy content of forages. Lower ADF indicates higher digestibility. Neutral detergent fiber is a measure of total structural carbohydrates in the plant. Total digestible nutrient is an estimate of all digestible organic nutrients (protein, carbohydrates, and fat in forage that are available to the animal. The NDF fraction is partially digestible. As such, NDF is considered an indicator of forage bulkiness and is related to dry matter intake. Lower NDF indicates more forage intake potential. Forages usually contain more than 30 percent NDF. Neutral detergent fiber and ADF both increase as forages mature, while DMD (or TDN) decreases.

Analyzed ¹				Calculated ¹			
Quality Standards	CP ²	ADF	NDF	TDN	DDM	DMI ³	RFV
Prime	>19	<31	<40	>60	>65	>3.0	<151
1	17 – 19	31 - 55	40 - 46	59 - 56	62 - 65	3.0 - 2.6	151 - 125
2	14 – 16	36 - 40	47 - 53	55 - 52	58 - 61	2.5 - 2.3	124 - 103
3	11 – 13	41 - 42	54 - 60	52 - 51	56 - 57	2.2 - 2.0	102 - 87
4	8 - 10	43 - 45	61 – 65	50 - 49	53 - 55	1.9 - 1.8	86 - 75
5	<8	>45	>65	<49	< 53	< 1.8	<75

Table 3.25. Hay quality classification based on forage testing.

¹Values in the columns are expressed in terms of percent dry matter, except for RFV and DMI. ²Abbreviatons over columns are: CP = crude protein; ADF = acid detergent fiber; NDF = neutral detergent fiber; TDN = total digestible nutrient; DDM = digestible dry matter; RFV = relative feed value; DMI = dry matter intake.

³Based on percent of body weight (% BW).

Source: Coppock, 1997.

Crude protein is a measure of the amount of nitrogen in the forage. Forages usually vary on their crude protein content depending on forage species, the stage of maturity, and fertilization practices (Table 3.25). Crude protein content in legumes ranges from 15 to 23 percent, while in grasses, CP levels range from 8 to 18 percent. Other crops residues used in grazing such as straw can have three to four percent CP. If the analysis report provides the percent of nitrogen, then the crude protein can be calculated by multiplying the total N concentration (%) by a constant, 6.25. The formula is: $CP = \% N \times 6.25$.

The relative feed value (RFV) is an index used to rank forages based on forage digestibility (ADF) and forage intake potential (NDF). RFV is not a percentage, and it measures the overall feed value of forage. The original RFV was developed for alfalfa but can be used to rank different grasses and legumes. Grasses typically have higher ADF and NDF concentrations and consequently have lower RFV. Grasses and corn silage also have a greater NDF: ADF ratio than legumes. Higher RFV values indicate higher forage quality. Since the RFV system was developed using legume forages, the relative forage quality (RFQ) index is more useful with warm-season forages because it uses fiber digestibility to estimate intake as well as the total digestible nutrients (energy) of the forage. In the calculation of RFQ values, total digestible nutrients (TDN) substitutes for digestible dry matter intake (DDMI) and TDN are calculated from fiber digestibility obtained in the laboratory. The RFQ is a much improved index than RFV for those that buy and sell forages, and it better reflects the performance that can be expected from feeding those forages.

Another piece of information in the forage quality report is that of net energy (NE). Net energy refers to the energy concentration in a feed. It can be measured directly only by expensive, laborious animal trials. However, it can be predicted using either NDF or ADF. Forages cut at different stages of maturity have different levels of fiber and energy (Table 3.26). Older, more

mature forages have higher fiber and less energy than younger, succulent forages. Net energy is calculated in megacalories (Mcal) per lb (hundredweight, 100 lb). This NE shows that 0.5 Mcal/lb is the same as 50 Mcal/100 lbs. Both NDF and DDM (as TDN) are needed in the equation because as a plant matures, the increase in NDF is large, while the decrease in DDM is not so great. Using both NDF and DDM increases accuracy of the net energy value.

Forage Quality Impacts

Formulating nutritionally balanced rations

Forage quality has a direct effect on animal performance, forage value, and, ultimately, on profits. When forage quality is low, forages alone may not support desired rates of animal performance. In such cases, it is necessary to provide livestock with supplements for protein and energy. The quality of forage has a dramatic effect on feed consumption. Knowing the nutritional value of the hay helps animal nutritionists in developing rations that will increase the efficiency of feed consumption. Hay quality can also be used to determine the value of the hay being purchased against standard commodity prices. Putting a dollar value on each pound of protein or each pound of energy being purchased will determine if the cost of feeding hay is feasible.

		Energy Type		
Maturity Stage	Digestibility	Gross	Digestible	Net
	(% DM)		(Mcal/lb)	
Vegetative	67	1.92	1.28	0.73
Boot	61	1.90	1.16	0.65
Head	51	1.92	0.98	0.49
Senescence	47	1.93	0.91	0.41

Table 3.26	Changes in	digestibility	and energy	levels of hav	at four	maturity stage
1 auto 5.20.	Changes in	ulgestionity	y and chergy	levels of hav	y at tout	maturity stage

Source: McCullough, 1989.

Developing and allocating forage inventories

Knowing the forage quality will help to allocate livestock to areas that need to be grazed immediately before quality starts to decline. It could be a very valuable tool in developing specific grazing management practices.

Evaluating forage management practices

The foundation of profitable livestock production is good forage management. Harvested feed is at an economic disadvantage when livestock prices are low and labor, machinery, and fuel costs are high. Hay quality is a reflection of how forage crops were harvested. Delaying forage harvest will compromise forage quality. Improper fertilization practices, especially nitrogen application, are reflected in the low protein value. Storage methods will also affect quality.

Marketing and pricing forages

This is where the market for hay production starts with producing high quality hay. When hay supply exceeds demand, producers are going to be more selective. Remember that high quality hay does not necessarily mean highest nutritive value. What is high quality to one person may be considered mediocre quality by someone else. Quality is in the eye of the beholder. It depends on who is buying the hay and their specific standards. For example, a horse owner might be interested in hay with good green color and ample leafiness with a lack of mold, odor, and dust. Determining if a specific targeted market will pay a sufficient premium for high quality hay should be part of the market analysis. This will help determine what harvest management system might best fit the operation. Forage analysis can be quite helpful in assessing nutritional quality, but an honest physical description of the hay is also helpful to buyers who cannot examine it before it is picked up or delivered. Quality is important for several reasons. Quality affects the target market for hay produced and the price received. Quality also affects production costs and practices. Producing higher quality hay will reduce the total quantity of hay produced and increase the cost of production.

Hands-on Activities

- 1. Trainees will learn how to collect a soil sample and process it. They will also learn about techniques to determine soil texture in the field.
- 2. Trainees will learn about forage quality and hay testing. They will learn how to identify hay lots, how to take a forage sample, how the sample is processed using a portable NIR and how to interpret the forage quality analysis.
- 3. Develop a forage ID system for producers to identify growth stages and distinctive characteristics of legumes and grasses.

Key Points

- 1. Forages are plants or plant parts eaten by animals or harvested, preserved and then fed to animals. Various harvesting, preservation, feeding and management methods may be used in forage production systems. It important to have a forage production system balanced with soil fertility, species selection and good establishment before a grazing management strategy is implemented. Soil sampling is a key component of plant nutrition and proper forage establishment.
- 2. Most goat production in the region will involve grass based forage systems. Meat goats must depend almost solely on forages to meet their nutritional needs if they are to be economically viable and the composition of forages commonly eaten by goats varies widely. One concern for a goat grazing management system is often uncertainty over the consistency of production and quality of pasture forage. A key strategy to address that concern is to include a diversity of forage species in the grazing system within and among pastures on the farm. Therefore, both cool- and warm-season grasses and legumes can provide much greater yields of high quality forage for goats than weeds and brush.
- 3. Forage quality also plays an important role in goat grazing systems since low quality forage could affect animal performance including weight gains, breeding cycles and animal health. Forage quality should be measured by determining the nutritional value of the forage. The color of a hay bale is frequently suggested as an indicator of the quality of the hay as a feedstuff, but hay color has almost no relationship to animal performance. Visual estimates are an essential part of hay evaluation to detect mold, foreign matter, leafiness, color, odor, sun bleaching, and maturity; but used alone they are unreliable as

indicators of forage nutrient content. Hay color has almost no relationship to animal performance; the only good indicator is forage testing.

4. The efficiency of feed conversion is important to reduce production costs. Goat producers should identify forage as a major focal point for farm development. The development of a forage management plan should reflect soil capabilities, topography of the farm as well as desired management intensity of the farm manager.

References

- Adesogan, A.T., L. E. Sollenberger, Y.C. Newman, and J.M.B. Vendramini. 2009. Factors Affecting Forage Quality. Univ. of Florida Coop. Ext. Serv. Pub. SS-AGR-93. Accessed Oct. 19, 2012. http://edis.ifas.ufl.edu/pdffiles/AG/AG16100.pdf.
- Adjei, M. B., J. D. Arthington, and A. R. Blount. 2006. Forage Testing. Univ. of Florida Coop. Ext. Serv. Pub. SS-AGR-63. Accessed Oct. 19, 2012. http://edis.ifas.ufl.edu/pdffiles/AA/AA19200.pdf.
- Anonymous. 2000. Soil nutrient recommendations for Alabama Crops. Accessed Oct. 19, 2012. http://www.ag.auburn.edu/agrn/croprecs/service.html#FertRecs.
- Anonymous. 2012. Weed Control Guidelines for Mississippi. Mississippi State Univ. Coop. Ext. Serv. Pub. 1532. Accessed Oct. 19, 2012. http://msucares.com/pubs/publications/p1532.pdf.
- Ball, D. M., C. S. Hoveland, and G. D. Lacefield. 2002. Southern Forages. 3rd Ed. International Plant Nutrition Institute. Norcross, GA.
- Ball, D. M., C. S. Hoveland and G.D. Lacefield. 2006. Forage Crop Pocket Guide. International Plant Nutrition Institute. Norcross, GA.
- Ball, D., M. Collins, G. Lacefield, N. Martin, D. Mertens, K. Olson, D. Putnam, D. Undersander . and M. Wolf. 1997. Understanding Forage Quality. American Farm Bureau Federation, Park Ridge, IL. Pub. 1-01. Accessed Oct. 19, 2012. http://www.uwex.edu/ces/forage/pubs/FQ.pdf.
- Barnhart, S.K. 2004. Forage Sampling and Sampling Equipment. Iowa State Univ. Coop. Ext. Serv. Pub. PM-1098b. Accessed Oct. 19, 2012. http://www.extension.iastate.edu/Publications/PM1098B.pdf.
- Beck, P.A., C.B. Stewart, J. M. Phillips, K.B. Watkins, and S.A. Gunter. 2007. Effect of species of cool-season annual grass interseeded into bermudagrass sod on the performance of growing calves. J. Anim. Sci. 85:536-544.
- Brady, N.C. and R.R. Weil. 2000. Elements of the the nature and properties of soils. 12th ed. MacMillan Publ. Co. New York.
- Chamblee, T. N. and R. L. Todd. 2002. Mississippi broiler litter: Fertilizer value and Quantity produced. MAFES Research Report 23 (5). Accessed Oct. 19, 2012. http://msucares.com/pubs/researchreports/rr23-5.pdf.
- Coppock, C. E. 1997. Adjusting Rations to Forage Quality, and Suggested Criteria to Use in Buying Forages. Proc. 3rd Western Dairy Management Conference, Las Vegas, Nevada: 138-143.
- Crouse, K. and W. McCarty. 2006. Soil Testing for the Farmer. Mississippi State Univ. Coop. Ext. Serv. IS346. Accessed Oct. 19, 2012. http://msucares.com/pubs/infosheets/is0346.pdf.

- Dietz, H. E. 1989. Grass: The Stockman's Crop, How to Harvest More of It. Sunshine Unlimited, Inc. Lindsborg, KS.
- Evers, G.W., L.A. Redmon and T.L. Provin. 2004. Comparison of Bermudagrass, Bahiagrass and Kikuyugrass as a Standing Hay Crop. Crop Sci. 44:1370-1378.
- Fertilizer Use and Price. Economic Research Service. U.S. Dept. of Agriculture. Accessed Oct. 19, 2012. http://www.ers.usda.gov/data-products/fertilizer-use-and-price.aspx.
- Gaskin, J., G. Harris, A. J. Franluebbers and J. Andrae. 2007. Poultry litter application on pastures and hay fields. Univ. of Georgia Coop. Extension. Bull. 1310. Accessed Oct. 19, 2012.

http://www.caes.uga.edu/applications/publications/files/pdf/B%201330_2.PDF.

Griffin, T. S. 2004. Forage Facts: Selecting forage crops for your farm. Univ. of Maine Coop. Ext. Serv. Bull. 2272. Accessed Oct. 19, 2012.

http://www.umext.maine.edu/onlinepubs/PDFpubs/2272.pdf.

- Google Earth. 2013. Version 6.1.0.5001. Accessed Feb. 18, 2013. http://www.google.com/earth/index.html.
- Hall, M. H. 1994. Forage Quality Testing: Why, How, and Where. Penn State Coop. Ext. Serv. Ag Facts 44. Accessed Oct. 19, 2012. http://pubs.cas.psu.edu/freepubs/pdfs/uc115.pdf.
- Hancock, D. W., G. H. Harris, R. W. Franks, S. P. Morgan, and T. W. Green. 2011. Soil and Fertilizer Management Considerations for Forage Systems in Georgia. Univ. of Georgia Coop. Ext. Serv. Bull. 1346. Accessed Oct. 19, 2012. http://www.caes.uga.edu/applications/publications/files/pdf/B%201346 3.PDF.
- Henning, J. C. and H. H. Wheaton. 1996a. Establishing Forages. Univ. of Missouri Coop. Ext. Serv. Pub. G-4650. Accessed Oct. 19, 2012. http://extension.missouri.edu/p/G4650.
- Henning, J. C., G. D. Lacefield, and D. Amaral-Phillips. 1996b. Interpreting Forage Quality Reports. Univ. of Kentucky Coop. Ext. Serv. Pub. ID-101. Accessed Oct. 19, 2012. http://www.uky.edu/Ag/AnimalSciences/pubs/id101.pdf.
- Hevetter, K and G. Cuomo. 2001. Managing pastures for long-year supply. Univ. of Minnesota Coop. Ext. Serv. Lesson 6. Accessed Oct. 19, 2012.

http://www.extension.umn.edu/beef/components/homestudy/plesson6.PDF.

- Hoveland, C. S. 1999. Roots. The Georgia Cattleman. Vol. 7, p.19
- Jennings, J. 2005. Forage Legume Inoculation. Univ. of Arkansas Coop. Ext. Serv. Pub. FSA-2035. Accessed Oct. 19, 2012. http://www.uaex.edu/Other_Areas/publications/pdf/FSA-2035.pdf.
- Jennings, J. and L. Espinosa. 2006. Arkansas Nutrient Management Planner's Guide. Accessed Oct. 19, 2012.

http://www.arnatural.org/environmental_management/water/nutrient_mgmt/planners_gui de/.

Jennings, J., K. Simon, P. Beck, and S. Gadberry. 2012. Grazing Stockpiled Forages to Reduce Hay Feeding During Fall and Winter. Univ. of Arkansas Coop. Ext. Serv. Pub. FSA3133. Accessed Oct. 19, 2012.

http://www.uaex.edu/Other_Areas/publications/PDF/FSA-3133.pdf.

- Johnson, G. and R. Smith. 2004. Stockpiling Tall Fescue. Crop and Soil Environmental News. Virginia Tech.
- Johnston, A., and R. Mikkelsen. 2006. Forage Fertility Planning for 2007. Potash & Phosphate Institute (PPI). Ref. # 06080.

- Koenig, R., M. Nelson, J. Barnhill and D. Miner. 2002. Fertilizer Management for Grass and Grass-Legume Mixtures. Utah State Univ. Coop. Ext. Serv. Pub. AG-FG-03. Accessed Oct. 19, 2012. http://extension.usu.edu/files/publications/publication/AG-FG-_03.pdf.
- Lacefield, G., M. Ranaske, and J. Henning. 2002. Inoculation of Forage Legumes. Univ. of Kentucky Coop. Ext. Serv. Pub. AGR-90. Accessed Oct. 19, 2012. http://www.ca.uky.edu/agc/pubs/agr/agr90/agr90.pdf.
- Lemus, R. 2009. Hay Testing and Understanding Forage Quality. Mississippi State Univ. Coop. Ext. Serv. Pub. 2539. Accessed Oct. 19, 2012. http://msucares.com/pubs/publications/p2539.pdf.
- Maguire, R., M. Alley, W. Flowers. 2009. Fertilizer Types and Calculating Application Rates. Virginia Coop. Ext. Serv. Pub. 424-035. Accessed Oct. 19, 2012. http://pubs.ext.vt.edu/424/424-035/424-035 pdf.pdf.
- Marsalis, M.A., G.R. Hagevoort, and L.M. Lauriault. 2009. Hay Quality, Sampling, and Testing. New Mexico State Coop. Ext. Serv. Circular 641. Accessed Oct. 19, 2012. http://aces.nmsu.edu/pubs/_circulars/CR-641.pdf.
- Martin, N. P., R. L. Ellingboe, and J. G. Linn. 1988. Hay sampling and testing. Proc. National Alfalfa Symposium, St. Joseph, Missouri. Putnam, D., V. Owens, T. Ackerly. 2000. NFTA listing of hay probes: 92-102.
- McCullough, M. E., 1989. Roughage for Dairy Cattle. Hoard's Dairyman.
- Meyer, D. W. 1999. Forage Establishment. North Dakota State Coop. Ext. Serv. Pub. R-563. Accessed Oct. 19, 2012. http://www.ag.ndsu.edu/pubs/plantsci/hay/r563w.htm.
- Moore, K. J., L. E. Moser, K. P Vogel, S. S. Waller, B. E. Johnson and J. F. Pedersen. 1991. Describing and Quantifying Growth Stages of Perennial Forage Grasses. Agron. J. 83: 1073-1077.
- Owens, M., and N. Thiex. 2002. Take an Accurate Forage Sample. South Dakota State Univ. Coop. Ext. Serv. Pub. ExEx4001.
- Peters, J.B., K.A. Kelling, and E.E. Schulte. 1996. Choosing Between Liming Materials. Univ. of Wisconsin Coop. Ext. Serv. Pub. A3671. Accessed Oct. 19, 2012. http://learningstore.uwex.edu/assets/pdfs/a3671.pdf.
- Rayburn, E. B. 1993. Plant Growth and Development as the Basis of Forage Management. West Virginia Coop. Ext. Serv. Accessed Oct. 19, 2012. http://www.caf.wvu.edu/~Forage/growth.htm.
- Rayburn, E. 2003. Forage Management. West Virginia Univ. Coop. Ext. Serv. Sept. Bull. 5828. Accessed Oct. 19, 2012. http://www.caf.wvu.edu/~forage/forglvst/5828.pdf.
- Scarbrough, D.A., W.K. Coblentz, K.P. Coffey, J.E. Turner, G.V. Davis, D.W. Kellogg, and D.H. Hellwig. 2001. Effects of calendar date and summer management on the in situ dry matter and fiber degradation of stockpiled bermudagrass. J. Anim. Sci. 79: 3158–3169.
- Spears, J. F. and J. T. Green. 2001. Forage Seed Selection and Quality. North Carolina Coop. Ext. Serv. Pub. AGW-004. Accessed Oct. 19, 2012. http://www.cals.ncsu.edu/agcomm/forage/.
- Schroeder, J. W. 1996. Quality Forage for Maximum Production and Return. North Dakota State University Coop. Ext. Serv. Pub. AS-1117. Accessed Oct. 19, 2012. http://www.ag.ndsu.edu/pubs/ansci/range/as1117.pdf.
- Stichler, C. and D. Bade. 1998. Managing for High-quality Hay. Texas AgriLife. Pub. L-5219. Accessed Oct. 19, 2012. http://ector.agrilife.org/files/2011/07/qualityhay 4.pdf.

- Tisdale, S. L. and W. L. Nelson. 2005. Soil Fertility and Fertilizer, 7th ed. MacMillan Publ. Co. New York, NY.
- Undersander, D., R. Shaver, J. Linn, P. Hoffman, and P. Petterson. 2005. Sampling hay, silage, and total mixed rations for analysis. Univ. of Wisconsin Coop. Ext. Serv. A2309. Accessed Oct. 19, 2012. http://learningstore.uwex.edu/assets/pdfs/A2309.pdf.
- Usherwood, N. R. 1998. Nutrient Management for Quality Forages. News & Views. International Plant Nutrition Institute. Norcross, GA. Accessed Oct. 12, 2012. http://www.ipni.net/ppiweb/ppinews.nsf/0/5bb57ef7e29f502b8525691c005e2806/\$FILE/ 98100-NRU-Forages.pdf.
- Waller, S.S. 1985. Understanding grass growth: The key to profitable livestock production. Trabon Prince Co. Kansas City, MO.
- Web Soil Survey. United States Dept. of Agriculture: Natural Resources Conservation Service. Accessed Oct. 12, 2012. http://websoilsurvey.nrcs.usda.gov/app/HomePage.htm.

CHAPTER 4 ANIMAL GRAZING BEHAVIOR, INFLUENCE OF GRAZING ON PASTURES, AND GRAZING SYSTEMS

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Introduction

There are different grazing systems. Depending on pasture productivity, quality, forage species present in the pastures, and livestock type and species in a herd, one or another system should be implemented to get maximum benefits without hurting the pasture. To be able to do so, a livestock producer/manager should be familiar with all grazing systems, and select the one or combination of a few that is best suited to the farming situation and need. To comprehend the need for an appropriate grazing system, it is necessary to understand the grazing behavior of animals and how the grazing action influences plants and soils in pastures.

Animal Grazing Behavior

Goats are very selective grazers. Given a variety, they select and graze most palatable plants and plant parts first and less palatable ones later on. Generally, young, succulent shoots and leaves are more palatable than mature, woody stems, and older leaves. When there are multiple species in a pasture, a few species may be more palatable than others. So, most palatable species will be grazed repeatedly as long as goats can access them, which causes low availability or extinction of such species under uncontrolled grazing. Therefore, pastures having multiple species should be managed with controlled or rotational grazing. Like selecting palatable plants, goats select comfortable spots to rest.

During hot weather, goats gather around where shade (Fig. 4.1) and/or water are present to keep them cool. Goats graze in the cooler portion of a day and rest under shade and near water source when it is hot, causing frequent trampling around the resting areas. Trampling is also high around salt and feed supplement spots. So, it is good to provide natural shade to animals away from the water source and change supplementary feeding spots from time to time so that their distribution is divided into different areas which will minimize soil trampling in some particular area. Where there is no natural shade (tree), it is necessary to provide some artificial shade in the pasture so that animals are not stressed too much on very hot, cold, or windy days. Moreover, it is important to develop shelter for goats in pastures so that they can be protected from rain. Goats do not like to get wet.



Figure 4.1. Goats congregated under the tree shade on a hot day, July 2012, Tuskegee, Alabama, USA.

When a pasture has different vegetation density at different spots, goats prefer to graze in areas with less dense vegetation and avoid areas with a thick sod.

How Grazing Goats Influence Pastures

Goats and other grazing animals influence pastures mainly in three ways: defoliating pasture plants, trampling the pastures, and recycling nutrients (Karki and Gurung, 2009). Each of these actions is briefly described below.

Defoliation

Defoliation is the removal of plant leaves and shoots. Grazing animals defoliate forages thereby reducing forage shoots significantly (Fig. 4.2). Defoliation affects pastures differently depending on the forage species, selective grazing, defoliation frequency, amount of plant-food reserve and leaf area left after defoliation, the physiological stage of the plant being defoliated, and weather conditions at the time of defoliation. Defoliation reduces leaf area and plant-food reserve, ultimately influencing shoot development, shoot and root growth, light interception, soil temperature, and soil moisture. Grazing frequency and intensity should be kept at optimum level to avoid the untoward effects of overgrazing or undergrazing on the forage plants. Also, grazing should be initiated at the right physiological stage of forage plants.



Figure 4.2. Crimson clover-ryegrass mixed pasture before (a) and after (b) grazing, spring 2012, Selma, Alabama, USA.

Heavy and close grazing is harmful to certain grasses, such as orchardgrass, especially at the time when their growing points are being elevated prior to flowering. Continued overgrazing of tall-growing forage species generally weakens plants with reduced root systems, lowers forage yield, increases soil erosion and water run-off, and favors weed invasion. Continuous close grazing favors prostrate species like bahiagrass and common bermudagrass over taller species such as switchgrass and coastal bermudagrass. Conversely, undergrazing or intermittent grazing facilitates the survival of tall species. Also, a significant amount of pasture biomass is wasted and forage quality goes down as forage plants mature in under-grazed situations. Moreover, clover stands decrease in grass-clover pastures when under-grazed because of the shade effect of the taller grass on the shorter clover. However, there is a difference in shade tolerance among the clover types. For example, red clover is more tolerant of grass competition because of its upright growing nature. Similarly, crimson and subterranean clovers are more shade tolerant than arrowleaf clover. It is because arrowleaf buds do not develop near the stem base for initiation of new leaves under shade.

Appropriate frequency and height of grazing differs based on the growth pattern of forage species, such as erect, semi-erect, and prostrate. Erect species are easily defoliated by grazing and generally depend on food reserves in roots and/or stem bases for re-growth and persistence. It is because, as already mentioned, these species have only few leaves close to the ground (Fig. 2.5b), and most leaves are readily available for grazing as they remain up from the ground surface. Rotational stocking with a suitable rest period or continuous stocking at a rate low enough to leave higher stubble is required for erect species such as alfalfa, sericea lespedeza, pearl millet, sorghum, johnsongrass, big bluestem, Indiangrass, and switchgrass. Semi-erect species that have food storage and buds near the ground are fairly tolerant to close grazing except under stress conditions. Some of the species in this group include tall fescue, orchardgrass, and arrowleaf clover. Prostrate species like bermudagrass, bahiagrass, Kentucky bluegrass, white

clover, and subterranean clover are much more tolerant to close grazing compared to the erect and semi-erect species.

Trampling

It is obvious that when animals are in pastures, they exert a huge pressure on pastures as they stand, walk, or lie down. Hoof pressure of grazing animals on the pasture injures plants and compresses soil, which results in reduced pasture productivity. Pasture plants respond differently to trampling damage. Ryegrass, tall fescue, Kentucky bluegrass, bermudagrass, and white clover are more tolerant to trampling than small grains (oats, wheat, barley, and triticale), orchardgrass, or red clover. Trampling damage is greater on wet than dry soils, on clay than sandy soils, on recently tilled soil than settled soil, and on short forages than tall forages. Trampling of grazing animals on wet clay soils substantially reduces water infiltration, and increases surface runoff. Removing animals from pasture during extremely wet periods can reduce trampling damages in pastures.

Nutrient Recycling

Grazing animals recycle most of the nutrients removed from pasture back to it through defecation and urination. The excreta (urine and feces) of grazing animals accumulate nutrients on certain areas of the pasture, basically under shade and around the water source as well as feed supplemented area, if any. The excreta supply the organic matter and other mineral nutrients to the soil that enhances soil fertility. Uniform distribution of excreta in pastures is desirable; for this the watering and feeding facilities and shade have to be scattered accordingly.

Grazing Systems

Livestock professionals and producers need to be familiarized with different grazing systems and should be able to adopt the most suitable system to manage pastures sustainably, fulfill animals' nutrient requirements, promote animal health and performance, and lower production costs. Following are different grazing systems.

Continuous grazing: Under a continuous grazing system, animals are allowed to graze the whole pasture continuously throughout a grazing season each year. If a pasture has different forage species at different portions, animals may overgraze the portion where there are forages of their choice while undergrazing certain other portions that have less desirable forages. Managers do not have any control over where animals should graze within the pasture. Also, animals will select certain areas such as near water, under shade, and at the riparian habitat during hot days to graze and rest. As long as enough food is available in these areas, animals will hardly go to areas farther away. So, one can find a wide variation within a continuously grazed pasture with a few spots heavily grazed and other areas undergrazed, and some areas heavily trampled with significant soil exposure and a large amount of feces accumulated.

Rotational grazing: In a rotational grazing system, whole pasture is divided into two or more subdivisions (paddocks) through appropriate fencing, and animals are allowed to graze one paddock at a time and moved to another paddock in a sequence or rotation based on forage availability. If a pasture primarily has forage species resistant to continuous close grazing like

bermudagrass and bahiagrass, then a continuous grazing system is appropriate. However, a pasture having mixed species, some of which cannot tolerate continuous grazing, requires rotational grazing since animals will selectively graze more palatable species and avoid or minimize grazing on less palatable species.

Strip grazing: A strip of a pasture is fenced temporarily with a movable fence and animals are allowed to graze the strip for a short time, which may vary from a few hours to a couple of days depending on the strip size and forage availability. When the strip is grazed to a desirable level, the fence is moved to allow animals to move to another fresh strip.

Frontal grazing: Animals are allowed to access a limited area by means of a frontal fence; there will be no back fence. When the allocated area is grazed to a desired level, the frontal fence is moved to allow animals to graze a new area.

Limit grazing: Animals are allowed to graze a high-quality pasture such as legumes or winter annuals for a limited time, e.g., for few hours every day. Growing high quality forage on a separate piece of pasture and allowing animals on this pasture for few hours every day is useful to fulfill the nutrient requirements of animals grazing low-quality pastures during the rest of the day.

Mixed-species and single-species grazing: Single species grazing involves grazing a pasture by only one species of animals, such as grazing with goats or cattle only. Mixed-species grazing involves two or more species of animals, for example, cattle and goats grazing together. Mixing cattle and goats for grazing can be more beneficial than grazing either species alone because goats eat many plant species that would not be eaten by cattle, and cattle lower parasitic infestation in goats as the goat-worm larvae ingested with forages grazed by cattle are damaged when they are in the stomach.

Creep grazing: Smaller animals are allowed to go (creep) to a certain portion of pasture having higher forage quality through openings in a fence that allow smaller animals but prevent larger animals from entering. Creep grazing is practiced to fulfill the nutritional requirements of young growing kids grazing with their does and other mature animals.

Forward-creep grazing: Young kids are allowed to creep through a creep gate to a fresh pasture first and then does and bucks are allowed to graze the same paddock.

First and last grazer: When there are different classes of animals in terms of nutrition requirements, those requiring a high plane of nutrition are allowed to graze the fresh pasture first. Then other classes of livestock in sequence of nutritional requirements are allowed to graze. For example, the grazing sequence can be 1) lactating does in their early lactation, 2) young growing kids, and 3) dry does.

Grazing Terminology

Stocking rate and stocking density: Stocking rate is the number of animals stocked per unit pasture for a specified time period. Stocking density is the number of animals stocked per unit pasture at a point in time. For example, if 20 goats are stocked in a 4-acre pasture for a grazing

season, the stocking rate is five goats per acre. If the pasture is divided into four paddocks (1acre paddock each) and each paddock is grazed by 20 goats for seven days rotationally, then the stocking density is 20 goats per acre.

Seasonal stocking: The stocking rate may differ in different seasons depending on the forage availability. When there is enough moisture, suitable temperature, and required solar radiation for forage growth, forage availability will be high for a given piece of pasture. However, forage growth will go down as the climatic conditions become adverse, and available forage in the same piece of pasture will decrease. So, stocking density should be adjusted in each season depending on the forage availability, or supplemented with hay or other feedstuffs to maintain the same stocking rate throughout a grazing season.

Key Points

- 1. Grazing animals prefer to graze the most palatable forages and most succulent portion of plants first, and less palatable and more fibrous portion later on when there is no selection available.
- 2. Grazing animals influence pastures by defoliating pasture plants, trampling pasture plants and soils, and recycling nutrients taken from grazing back to the pastures through urination and defecation.
- 3. There are different grazing systems, such as continuous, rotational, strip, creep, forward creep, first and last grazer, frontal, mixed species, and limit grazing.
- 4. Grazing managers and producers need to understand the concept and practicality of these grazing systems and adopt the most suitable ones for the sustainable management of their pastures.

References

Karki, U. and N. K. Gurung. 2009. Year-round pasture production and management. Cooperative Extension Program, Tuskegee University, Publication No. TULV 0709-01 Livestock Production. Tuskegee, AL. p. 52.

CHAPTER 5 FACILITIES FOR PASTURE-BASED GOAT PRODUCTION UNDER CONTINUOUS, ROTATIONAL, AND OTHER GRAZING SYSTEMS

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Introduction

Some facilities are required for grazing, chiefly fence, but also facilities to supply water, supplements, and minerals. Fencing costs will nearly equal the investment in animals, so it is important to get a fence that will contain the animals and be cost effective for management and the type of pasture. Shelter is also required under various environmental conditions and must be done economically. Working facilities are a must, and most importantly how you work your animals will reduce stress on animals and the worker.

Fencing

Fencing for goats involves two different kinds of fence. The first is a perimeter fence which must contain animals securely, and the other kind of fence is a division fence for dividing the pasture into grazing paddocks. These will each be discussed separately due to the different requirements for each fence.

Perimeter Fence

The perimeter fence which goes around your property must be secure to prevent your animals from escaping to the neighbors and causing damage or escaping onto the roadway where they may become not only a hazard, but have great potential for liability. For this reason, the perimeter fence must be very secure. It may also be useful to deter predators. In addition, the perimeter fence often needs to be placed on the property line since fences serve as a property boundary. Since constructing the fence requires working close to or on your neighbor's property, you need to obtain your neighbor's permission. It is often wise to have the property surveyed since someone may have made a mistake where they put the existing fence and it may not be on the property line. Your local government entities may also require a permit for fence construction.

Since perimeter fences must be secure, conventional fencing such as sheep and goat net wire and 8-10 strands of barbed wire are often utilized. Sheep and goat wire is often referred to as 10-47-12 net wire. It has 10 strands of wire running the length of the fence, is 47" high and the stay wires running up and down are 12 inches apart. This is important as goats stick their heads through conventional field fence (with 6-inch spacing) and cannot pull their heads back because their horns prevent them. The 12-inch spacing enables them to turn their head and pull their nose back through first. There is a high tensile version of 10-47-12 fencing available which has a

longer useful life because of its springiness. It will not stretch or bag out from animals rubbing against it. If a tree falls on the fence, when the tree is removed the fence springs back to its original tightness. Another popular goat fence is 4×4 " wire which is 48" high and has both 4" spacing of vertical and horizontal wires giving 4" by 4" holes. It is fairly predator resistant and animals (except young kids) cannot put their head through to be entrapped. These two fences may have a strand of barbed wire below to prevent predators from sliding under the fence and may have a strand of barbed wire on top to keep large animals from putting their head over the fence and stretching the fence down. Care must be taken to build strong corner braces since braces are so important to the life of the fence.

If the property has a five-strand barbed wire fence in good shape, it can be modified to hold goats by adding three strands of barbed wire down low so that there is no space greater than 7" between wires, and use stay wires between the posts to hold the wire spacing. This is a fairly cheap way to modify the fence for goats and requires a moderate amount of labor. Two strands of electric wires on outriggers at 10 and 20" height can also be an effective method of modifying five-strand barbed wire fences to hold goats in. Electric fence can also be suitable for perimeter fences. On rented properties or when using goats for vegetation management on land you do not own, electric fence is often the only fence that is cost effective for utilizing those opportunities.

High Tensile Fence

High tensile fence is one of the most trouble-free, secure fences that one can put up and therefore makes an excellent perimeter fence. High tensile fences are usually electrified for goats to both keep goats in and predators out. High tensile fences utilize strands of high tensile wire which is very strong and springy. The corners must be built very secure because the wires are pulled very tight. The wires are connected to corner posts using an insulating tube around the wire or with special type insulators that can withstand the pull of the tight wires. Many types of line posts can be used. They may be fiberglass T posts, fiberglass sucker rod, plastic composite posts, or even wood posts with high quality insulators. Fence tighteners are placed in the middle of runs of the wire to tighten the fence to the proper tension.

The fence is often constructed so that sections may be shut off with a switch to help isolate shorts or reduce the load on the energizer . Sometimes a switch may be used to cut off the lower wire in case it gets overgrown by grass and weed growth and loads the energizer excessively. The most popular wire used for high tensile fences is 12 gauge wire with 180,000 PSI rating, which means that one strand of wire will withstand 800 or more lbs of strain before it breaks. The wire has Class III galvanizing, which refers to the amount of zinc on the wire, and as such will last many years longer than conventional galvanizing. Sometimes 14 gauge high tensile wire is utilized on division fences and semi-permanent fences. A number of fence supply companies can provide detailed information on supplies and construction of high tensile wire fences. There is also significant information available on the web.

Electric Fence

Electric fence works well for goats, but requires more management than for conventional fence. Some managers are not able to manage electric fence or commit the time to check the voltage every day and therefore cannot effectively utilize electric fence. The advantages of electric fence are that it is much cheaper than conventional fence, helps to deter predators, and works well for containing goats. Four or five strands of electric fence are very suitable for perimeter fences. If it is a permanent installation 12 gauge high tensile wire should be used on fiberglass T-posts or fiberglass sucker rods from the oil field (cheap, long lasting, but require special clips available from Kencove fencing and other companies). There are many types of self-insulating posts from various fencing supply stores. Using insulators on steel T posts is not a good practice because when the wire gets knocked off the insulator, the wire will short (or ground) against the metal post and severely reduce voltage on the fence. If the fence is temporary, step in posts can be used with 14 gauge high tensile wire. High quality polywire (especially the 9 conductor variety) may also be utilized and has an advantage in that it is easy to roll up when the fence is moved, but generally costs more than high tensile wire.

Internal Division Fence

Internal division fences are used to divide the property into pastures to manage grazing to increase pasture production or reduce parasite problems. If you are utilizing goats for vegetation management, you may not need division fences. Internal division fences do not require the security of a perimeter fence since if the goat escapes, he is still confined by the perimeter fence. Internal division fences are often temporary, but can be permanent. It is probably best to use temporary fence for internal division fences for a couple of years before you install permanent fences so that you will know where you want to put fences for sure. The manager needs to look at the soil map and vegetation before building a division fence since fenced areas should be as homogeneous as possible as to soil type and vegetation. If fields are not uniform, the goats may concentrate on one type of vegetation or soil series and overgraze that part and underutilize the remainder of the pasture. Your local Natural Resource Conservation Service Office may be able to provide information on soil types and vegetation and provide advice on division fencing. The watering system is also a consideration when designing the internal fences. Goats may be watered out of a pond.

Internal division fences may be made of conventional 10-47-12 sheep and goat wire on T-posts. If the T post is located in the middle of the vertical wires of net fence, it may provide opportunity for the goat to get his head trapped. The post may need to be moved. Multiple strands (8-10) of barbed wire will work well for a division fence. However, since security requirements are not as great for internal division fences, it is attractive to use cheaper types of fencing including electric fence.

Portable Electric Fence

Portable electric fences can be used for interior fences, especially when one is grazing the paddock for the first two years or if finances are limited. Electric fencing can help deter predators since canines are very aversive to being shocked, but once they discover how tasty goat is they will endure the shock for another taste of goat. Fiberglass T posts and fiberglass rod posts, fiberglass sucker rods, and step-in posts are all suitable posts. It is also possible to use wood posts with insulators. Polywire can be placed on step-in posts to provide an economical and very portable fence. It is important to use high quality polywire that has nine conductors

because the lower wires on a goat fence make it susceptible to being shorted out. Four strands of polywire equally spaced from hip high to the ground are adequate to contain goats. Corner insulators and a stronger post are needed for the corners. A small wooden post can be sharpened and driven as a corner post or a steel T post can be covered with a section of 1 2" PVC pipe to prevent shorting can also make a suitable corner post. Like other electric fencing, if the soil is dry, the fence will not deliver an effective shock. One solution is to ground every other wire of the fence so that the animal will be putting his head between a ground wire and a hot wire if he tries to escape and receive a powerful shock.

Electrified net wire is available from many suppliers. It can work well, but requires a higher level of management. It also has a benefit in that it is effective in deterring predators. The area it is to be set up in needs to be mowed or cut with a grass trimmer. This is because the lower wires are close to the ground and make it susceptible to shorting. Care must be taken during installation not to hook one of the lower wires on the metal part of the post that goes into the ground, which will short the fence. One must be careful when rolling up or unrolling the netting so that it does not get tangled or torn. In areas where the ground is dry, pos-neg electrified is available in which every other wire serves as a ground wire.

There are several secrets to the successful use of electric fencing. The first is to put the fence up using proper construction techniques and quality materials. Several companies that sell fencing materials have books on construction techniques. It is best to find someone in your area that has used electric fencing successfully for years and learn construction techniques from him or her. Often local farm store electric fence supplies are low quality because they are cheap. Investing a little more in quality will reduce the necessity to troubleshoot a fencing problem and increase the lifetime of the fence.

The second rule is to train your animals to the fence prior to putting them into it. This can be easily done by putting a sample of fence across the corner of a pen or trap and electrifying it (at least 7,000 volts). One can put a bale of hay out to provide incentive to cross the wire. In a day or two, the goats know how to respect the fence. Goats that insist on getting out of electric fence or conventional fence will train and lead others to escape. This behavior can be cured using a generous amount of barbecue sauce over low heat (fence jumpers make excellent barbecued goat meat). These animals must be culled. Some producers who purchase large numbers of stocker goats train animals by crushing aluminum soft drink cans from top to bottom and hanging the tab on the fence which attracts the goat's attention as they dangle in the wind and when goats nose the can, they get shocked.

The third rule of successful fence use is to **check the voltage** every day and fix the fence if you do not have at least 4,500 volts on the fence. Modern electronic volt meters will measure fence voltage while you are on your 4-wheeler and point the way to the short. These are essential for practical electric fence use and should be purchased when you purchase an energizer. The electric fence will kill a limited amount of vegetation that touches the conductor. A significant amount of vegetation will load the energizer and severely reduce fence voltage. Shorting from vegetation can be corrected by mowing or using a grass trimmer under the fence (be sure to turn the energizer off while doing this), or Glyphosate herbicide (Round-up) can be sprayed in a

narrow band under the fence. Sometimes animals will graze under the lower wire and prevent shorting.

Energizers

There are several guidelines for purchasing a fence **energizer**. They usually relate to joules, a measure of energy. Most recommendations are based on cattle fences which are much higher off the ground and therefore less prone to vegetation loading the fence; cattle also require less voltage to keep them inside the fence. Often locally available energizer units are more suitable for cattle and there is not qualified local expertise to recommend an energizer. Generally, one should buy as much energizer as one can afford as this will reduce problems with grass and weeds shorting the fence. You should have at least 0.25 joule for every mile of wire that is electrified (if you have one mile of fence with 4 wires, it requires 1 joule). However, there are other factors in addition to joules to be considered in selection of an energizer. There are several mail order fence businesses that have expertise on selection of an energizer for use with goats. An underpowered energizer will train animals to ignore electric fences and make the fence worthless.

The first decision about an energizer is what source of power will be used. Some energizers are powered by 110 volt electricity, some are solar powered, some are battery powered, and some can use more than one source of power. In general, if there is a source of 110 volt electrical power close at hand, a 110-volt energizer is more suitable because they are cheaper for the amount of power than other types of energizers and tend to be more reliable. When there is no electricity close by, one must use battery or solar power. The battery power units are useful when they are used for a limited amount of time each year as one gets tired of replacing and charging batteries. Solar powered energizers work well, but are more expensive than plug in energizers for the same power. When the fence must be energized for a long period of time, solar-powered energizers are more reliable than battery units and require less labor. The solar panel must be in full sunlight and cleaned occasionally.

Energizer Grounding

The **energizer** should be well **grounded** as grounding may become a limiting factor in the effectiveness of an energizer. Generally, about three feet of ground rod is required per joule of energizer. If multiple ground rods are used they should be driven 10 ft from any other ground rod. Only use galvanized wire to connect the ground rods to the energizer. Also use a lightning arrester on the electrical input side of the energizer as well as on the fence side. There are several good web sites that can provide information on hooking up a fence energizer. For rotational grazing, the fences being used can be energized from the perimeter fence. An alternative is to have the fence charger centrally located and grounded and run a conductor such as Maxi-shock (by Premier) on a spool out to the fence for power.

Hands-on Activities

A portable polywire fence will be set up by the class. The class will install a section of electronet fence. A section of high tensile permanent fence will be viewed. How to install an energizer and appropriate grounding system for the energizer will be demonstrated.

Shelter

Natural **shelter** is cheap and should be utilized if possible for goats. Generally, for goats in the Southeastern US, protection from the wind during the winter and at times protection from cold rain are required. Pond banks, trees and brush, and other natural windbreaks are suitable for goats. Trees can provide some protection from the rain. During the summer, goats in drier areas may get by without shade, but often will benefit from shade. Shade is especially important for very young animals and in humid environments. Shade from trees will provide adequate protection from the sun.

Purchase or construction of shelters for goats is expensive. Sometimes unused materials can be recycled into a suitable shelter. An example is a producer who acquired some trailer truck cab fairings and utilized these as windbreaks for animals. A producer built a roof on a house trailer frame for a portable shade. We built a shade on a hay trailer chassis that was 10 ft high and 12 x 24 ft which provided excellent shade for a 50-head herd. A mineral feeder was attached to it and it was moved from pasture to pasture with the animals using a tractor. Used grain tanks have been cut in half to provide shelter for goats. A possibility for shelter is use of some windbreak plastic netting on PVC frames as shown in

http://www.sheep.cornell.edu/management/feeding/wintergrazing/windbreak.html

There are a number of portable metal buildings that can be purchased for goats such as the Porta Hut©, a metal Quonset shaped structure on skids that can be dragged from pasture to pasture. There are also plastic polydomes that provide shelter from the wind and cold. Metal or plastic shelters that are enclosed are hot inside and are not suitable shades during the summer. One can rig tarps on posts to provide suitable shade during the summer. One producer used some surplus tents to provide shelter for goats. It must be remembered that whatever shelter is provided, there must be adequate ventilation to prevent pneumonia. Shelters will need to have the manure cleaned out regularly.

Hands-on Activities

The class will view different types of shelters and discuss the benefits and limitations of different kinds of shelters.

Goat Working Facilities

Working facilities are very useful if the herd has over 12 goats. **Good working facilities** reduce labor and injury to the operator while making the operation less stressful to the animals. A good set of handling facilities can be built out of cattle panels, T posts, and plywood. Metal working facilities are available for sheep and goats but are expensive and may not work well for goats. It is probably best to build your own and improve it as you see fit. One producer took two gates and put them in his barn 30" apart and fills the chute with animals, does FAMACHA and deworming, or gives vaccinations. He has a plywood gate at either end of the chute. This has been adequate for his 200 head herd. If working facilities are built inside a barn, make sure that you have sufficient light to read numbers and see animals' eyes.

Working Facility Design

You need to determine what activities you are going to use your working facility for to develop a **working facility design**. Will you weigh animals in it? Do you need to trim feet and/or treat for foot rot? Do you plan to sort animals? Will you do FAMACHA and deworm in it? Do you plan to vaccinate animals or evaluate soundness and sort them out for culling. After listing activities that you plan to do, you need to plan for appropriate equipment to accomplish these tasks. If you plan to weigh, you will need a scale and then figure out where you want to place it. If you plan to trim feet on a number of goats, a turning cradle will be useful. Vaccinating and FAMACHA can be done either working outside a narrow chute (may be tapered slightly from top to bottom) or inside a wider chute such as 32" where animals are treated and moved behind the worker when done with them. This is popular in Australia and New Zealand because animals can be worked faster. Goats can be examined for soundness (teeth, bag, and feet) and be marked on the forehead with a marking crayon and these animals be sorted off as they exit the chute. Caution, Spanish goats will tend to pile up in a long chute and chute length should be limited to 10-12 ft. However, a longer chute can be used with a divider gate. If you plan to sort animals you need a sorting gate(s) and pens to sort animals into.

If you have plans for a working facility, it can be built with cattle panels and plywood and other miscellaneous. Work animals through it and you will have places where you want to improve it. This is a better approach than buying a metal working facility that you cannot change or improve to fit your needs and a lot cheaper. Portable facilities can be useful, especially when using goats for vegetation management or rented land. There are some commercial portable working facilities that are very nice but expensive, but if you work enough animals in them, it can be justified. You can build facilities in a pasture with T posts, panels, and plywood and take it down and move it. You can build a chute out of plywood to haul on a trailer or can use some gates, panels, or pieces of plywood to build a chute held in place with T posts. Horse panels which are 5-ft high, 20-ft long and have 4×4 " holes work well for collecting and working pens. They can be fastened to T posts and each other using baling wire or rubber tarp straps. Any animal that climbs this fence should land on a barbecue grill.

Goat behavior

There is an abundance of information on sheep behavior, but precious little on **goat behavior**. There is a chapter in Ron Kilgour's behavior book (1984) and a review of social behavior by Shackleton and Shank, 1984. There were several good articles related to goat behavior and fencing and handling goats put out by Australian workers when feral goats were being selected for cashmere. Since then, very little information outside of popular press articles on goat behavior or design of working facilities has become available. There is a need for scientific research on handling facilities for meat goats.

There are many ways to handle goats. One way is to use brute force which will get the job done, but it is hard on goats and humans. There is a smart way to work animals that depends on using the animals' natural behavior to get the animal to do what you want to do. For getting animals into the corral, a bucket of feed will work if the animals get a bite of feed once a week. If animals are being herded, you can herd them on foot slowly going back and forth behind the animals. Goats do not like for you to be behind them in their blind zone and will often stop and

look to see where you are. However, if you are singing, talking, or humming, they can tell where you are from the sound when you get in their blind zone and will keep moving.

As you crowd animals in, they are more willing to try to run past you (escape behavior). You can wave your arms or use a cane or stick to look wider than you are to discourage them. However, you can use this same escape behavior to get animals to run from a pen into another pen or chute. If you place yourself strategically to the front and side of where you want animals to go, they will run past you, escaping, but going where you want them to go. You may have to apply more pressure on them by advancing. Watch how animals respond to your position.

Hands-on Activities

Handling and processing facilities on site will be observed and animal movement will be demonstrated.

Watering Facilities

Providing water for goats can be expensive, but good planning on **water facilities** can save money. If there is an existing above ground water source such as ponds, it can be utilized by multiple pastures. Generally, a cattle panel can be fastened with T posts down into the pond to separate pastures and goats will not cross the pond to another pasture. Some Kiko goats have no fear of water unlike the rest of the goat population and could potentially cross. Natural springs can also be developed and utilized for watering animals. Sometimes it is cost effective to haul water to goats. With a small number of goats, one can haul sufficient water in barrels that can be tipped into the water trough. More animals may require a water tank on a trailer with hoses run to floats in water troughs.

If natural water supplies are not available or adequate, a water system must be developed. There may be an existing pressurized water system that can be utilized. If not, a well or other water source and pump are required along with piping to the troughs. Development of a water well is expensive, but may be necessary. If electricity is available, it is easier to power the water pump using commercial electricity. If no electricity is available, a solar pump may be utilized. Solar pumps generally pump water at a slower rate and usually into a gravity flow system. Development of a solar water supply takes some engineering and suppliers of solar pumps usually have the expertise to assist in designing a solar water system.

Water Lines

Piping from the water supply to the water troughs is very important. PVC or plastic pipes are often utilized. Sometimes plastic pipe is laid on top of the ground in pastures that are only grazed during the summer. Water line generally needs to be buried in pastures where goats are present during the winter. Local advice of the depth to bury pipe should be obtained. Gophers may chew the pipe if they are present unless gopher proof plastic pipe (SDR9) is utilized. The water line layout should be designed in a loop so that there are no dead water areas that will accumulate heavy bacteria loads. Generally a large size line is used such as 1-2" because with long runs, there can be a large pressure drop which reduces water flow. This is especially important for gravity flow systems where water pressure is limited.

Permanent waterers can be placed at every watering point and may be shared by pastures. Portable waterers can be used which are moved with the animals when pastures are rotated. Approximately 40 goats can be watered per square foot of surface water in the waterer. Waterer manufacturers have their own estimates of the number of animals that waterers will serve. Using portable waterers is cheaper than putting in a number of permanent waterers. Quick connects to the supply line facilitate moving portable waterers. They are installed in line and usually in a container such as a 5-gallon bucket buried in the ground with a lid. Insulation is often used over the quick connect to keep it from freezing in the winter. A line to the portable waterer is connected to the quick connect in the 5-gallon bucket in the ground. These quick connects shut off when water is disconnected and turn on when the connector is inserted. Many companies that sell electric fencing supplies also handle water system components including solar pumps and can assist in design of the water system.

Watering in Freezing Weather

Waterers can be permanent or portable. Permanent waterers should be installed on concrete or have a rock pad around them to prevent mud and associated disease problems. Portable waterers are moved before much mud accumulates. Waterers can be made from almost any container that will hold water. Some have even used tractor tires and buried the bead in a concrete pad. Permanent waterers may be frost-free, utilizing insulation and ground heat or electric heating if electricity is available. Some waterers can be made to leak and overflow slowly during freezing weather to prevent freezing. There are many kinds of portable waterers and float valves. There are special high flow float valves that fill the waterer faster which is important if a large herd has to be watered from a trough. However, the water system itself may limit water flow and not the float valve. Portable waterers can be made frost proof by drilling a small hole below water level. This leaks water slowly which keeps the valve and trough from freezing. The hole is plugged with a screw when it is not freezing. However, the water may form a large ice mass which may be a problem.

Hands-on Activities

The class will install a portable water system. The class will participate in planning the onsite installation of a watering system.

Feeding Nutritional Supplements

When pasture is inadequate in quantity or nutritional value, **nutritional supplements** must be fed to prevent a reduction in animal production. Nutritional supplements include a mineral supplement, or a grain supplement providing energy or protein while hay is often used to provide energy. Hay may be provided by small square bales, round bales, and occasionally from large square bales. While goats are very good at scavenging spilled hay, they will often foul hay if given the chance. In dry climates, slices of small square bales may be fed in open pasture on the ground and animals will utilize it well. Round bales can be rolled out, providing only enough hay for a day so that animals clean up the hay. Care should be taken to move the feeding area each day to prevent picking up parasites. In more moist environments, hay is best fed in a hay rack. There are many feeders that are suitable for goats. A feeder for small bales with either keyholes or slant bars will work well to keep animals from dragging hay out of feeders and wasting it.

Two feeders can work well for feeding round bales. One type holds the hay up about two feet or so above the ground and animals eat the hay from below. The other kind is a square that fits around the round bale on the ground and has holes for the animals to put their heads in and eat the hay. The sides collapse as the bale is consumed. Both can work well, but the elevated feeder requires equipment capable to lift the round hay bale into it.

Feeders for Grain or Concentrate Supplements

Grain or concentrate feed can be fed in a variety of feeders, depending on purpose. There needs to be sufficient feeder space so that all animals have space to eat and the dominant goat cannot keep other animals from eating. About 12-16" of linear feeder space are required per goat. However, one can tell by observation if feeder space is adequate. If coccidiosis is a problem, manure needs to be kept out of feeders or emptied or cleaned out of feeders so as not to spread the disease. Feeders can be made from pieces of five inch or larger PVC pipe cut in half and placed on the ground. There are many types of commercially available goat feeders, while some producers have recycled various metal boxes from the scrap yard. Some have built their own goat feeders such as out of metal pipe. Feeders placed on the ground are cheaper and more stable without the legs. Some feeders have various types of legs to get to a more convenient height and reduce the chance of getting feed contaminated by manure. Some feeders have a bar running the length of the trough about 18" high to try to keep animals from standing in the feeders and contaminating the feed. There are plans on the internet to build feeders out of wood. Occasionally, a self-feeder is used for goats. It is used for creep feeding kids and can be used for stocker animals. Some types of feeds have built-in feed limiters (such as calcium sulphate) to limit intake of the feed when fed from a self-feeder.

Feeders for Mineral Supplements

There are many different types of mineral feeders made of plastic, rubber, and metal available commercially. The purpose of a mineral feeder is to protect the mineral from the elements, especially rain, make the mineral readily available for mineral consumption, and prevent waste of the mineral. It should be easy to clean out and replenish the mineral. Mineral blocks can be fed in a truck tire fastened to a post or tree. There are commercial feeders with plastic or rubber tubs and rubber covers protecting the mineral from the rain that animals must lift up to get at the mineral. Placement of mineral feeders in a large pasture can help to concentrate grazing. In general, it is best to place minerals in the areas least frequented by goats to encourage them to graze the area more uniformly.

Anyone handy with nails and a hammer can build a mineral feeder as there are plans on the internet and in various books for building one from wood, PVC, or other materials. Various containers such as plastic drums can be modified for a mineral feeder. A feeder for loose minerals can be made from a pickup tire laying on its side and two halves of a tire bolted across the hole to provide a trough.

PVC pipe has also been used for constructing mineral feeders of which there are many examples on the internet. There are some mineral feeders designed for rotational grazing that can be pulled from one paddock to the other with a 4-wheeler. Construction of an economical mineral feeder is only limited by the producer's imagination.

Key Points

- 1. Fencing and watering facilities are critically important for grazing. Selecting the right type is very important for animal management and economic sustainability of the operation.
- 2. The cost of fencing is second only to the cost of the animals and therefore, it is important to select fence that will work for your operation and your pocketbook.
- 3. Working facilities will save labor and injury as well as reducing stress to the animal. Good facility planning reduces labor and costs associated with handling, feeding, and management of grazing animals.

References

Kilgour, Ronald. 1984. Livestock behavior. Westview Press, Boulder, CO.

Shackleton, D. M. and C. C. Shank. 1984. A review of the social behavior of feral and wild sheep and goats. J. Anim. Sci. 58:500-509.

Sources of fencing supplies and information

Premier Sheep Supplies 1-800-282-6631 <u>www.premier1supplies.com.</u> Kencove Farm Fence Supplies 1-800-536-2683 <u>www.kencove.com.</u> Powerflex Fence 417-741-1230 <u>www.powerflexfence.com.</u>

Other Information Resources

Couchman, R. 1981. Fencing, yarding and handling goats. Agnote No. 1666/81.
Joshua, E. 2003. Yard design for goats. Agfact A7.7.2 <u>www.agric.nsw.gov.au.</u>
Scheurmann, E. 1985. Behavior. In First International CASHMERE Seminar, Australian National University, Canberra, Australia.
Schoenian, S. 2003. Efficient handling of meat goats.

www.sheepandgoat.com/articleshandling.html.

Shurley, M. 2007. Meat goat facilities. In: T. A. Gipson, R. C. Merkel, K. Williams and T. Sahlu, editors, Meat goat production handbook. American Institute for Goat Research, Langston University, Langston, OK.

Squire-Wilson, T. and J. Browne. Yard designs for goats. Goat Notes B8. <u>www.ACGA.org.au/goatnotes/B008.php.</u>

Zweede-Tucker, Y. 2011. Meat goat handbook - Raising goats for food, profit and fun.Voyageur Press.

CHAPTER 6 SUITABLE PLANT GROWTH AND DEVELOPMENT STAGES FOR GRAZING AND GRAZING MANAGEMENT

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Introduction

After pasture development, it is very important to manage it sustainably for its persistence. For successful pasture management, one should know when to begin and end grazing without hurting forages much so that they can regrow vigorously after each grazing throughout the growing season. Additionally, grazing perennial forage species should end well in advance before they become dormant so that enough reserve food is available for their survival during dormancy and vigorous regrowth in the subsequent years.

Suitable Forage Height to Begin and End Grazing

As mentioned earlier, forages differ in grazing tolerance depending on their growth patterns. Erect species such as johnsongrass, switchgrass, and alfalfa are the least tolerant to grazing pressure, and the prostrate species such as bahiagrass, common bermudagrass, and white clover are the most tolerant to grazing. Semi-erect species such as tall fescue and orchardgrass are intermediate between the previous two categories of forages in grazing tolerance. Accordingly, the beginning- and ending-grazing heights for erect species are higher compared to the other two species categories (Table 6.1). Similarly, erect species require longer periods for recovering from the previous grazing compared to the other two categories; semi-erect species need longer recovery/resting periods than prostrate species (Table 6.1).

Grazing and Resting Periods

Grazing and resting periods apply in rotational or controlled grazing. During the grazing period, animals are allowed to graze in the given area of a pasture. When available forages are all eaten up by animals, they are moved out and the pasture area is left without any grazing animals in it so that pasture plants and soils can recover from the grazing pressures. This period is called resting period. The resting period should match with the growth cycle, which depends on the forage species, environmental condition, and time of the year. Since the growth cycle of most forages grown in the Southern States varies between 21 to 35 days, a rest interval of a similar period should be adequate for designing a rotational grazing system. A rest period of 21 days or less may be enough for cool-season forages under good growing conditions, while warm-season forages during dry summer months may need 35 days or longer for proper recovery.

	Target height (inches)		Usual recovery period
Forage crop	Begin grazing	End grazing	(days)
Alfalfa (grazing type)	10-16	2-3*	15-30
Bahiagrass	6-10	1-2	10-20
Bermudagrass	4-8	1-2	7-15
Big bluestem	15-20	10-12	30-45
Clover, white and sub	6-8	1-3	7-15
Clovers, all others	8-10	3-5	10-20
Dallisgrass	6-8	3-4	7-15
Eastern gamagrass	18-22	10-12	30-45
Fescue, tall	4-8	2-3	15-30
Indiangrass	12-16	6-10	30-40
Johnsongrass	16-20	8-12	30-40
Orchardgrass	8-12	3-6	15-30
Ryegrass, annual	6-12	3-4	7-15
Sericea lespedeza	8-15	4-6	20-30
Small grains	8-12	3-4	7-15
Switchgrass	18-22	8-12	30-45

Table 6.1. Guidelines for beginning and ending heights for grazing and recovery period for selected forages under rotational grazing.

Source: Ball et al., 2007.

*Ending grazing height must be four inches or higher for goats to minimize the internal parasite infection.

In Figure 6.1 we can see why stubble height needs to be different for forages with different growth patterns. Bluegrass and bermudagrass can withstand close grazing because most leaves that are close to the ground are left ungrazed, which can continuously involve in photosynthesis and manufacture food for plant re-growth. Additionally, stored food present in rhizomes and stolons of these forages supply nutrients for vigorous regrowth. Unlike these forage species, grazing should end at higher stubble height for orchardgrass and tall fescue to leave enough leaf area for photosynthesis after grazing.



Figure 6.1. The nature of forage growth patterns influence grazing height. Source: Blaser, 1986.

Harmful Effects of an Inappropriate Grazing/Harvesting

Grazing when plants are too young: Grazing should begin only when forages are established very well with enough leaf area and stored food available for plant regrowth after defoliation. Depending on the forage species, excess food (spared from that required for plant growth and development) from photosynthesis is stored in roots, stems and stem bases, crown, rhizomes, and/or stolons. The grazing manager should monitor the forage plant very well for available leaf area and well-developed food storage structures before grazing. If grazed when plants are too young (Fig. 6.2a), they will not be able to cope with the grazing pressure. As a result, plants may die, or show very poor regrowth. After couple of grazing cycles, the stand will be very poor with several patches without any forage. This situation requires replanting the pasture and providing enough recovery period before the next grazing can begin. On the other hand, if grazing begins when forages are ready for grazing (Fig. 6.2b) and ends when the desired stubble height is reached, forages will regrow and maintain a good stand provided enough recovery period.



Figure 6.2. Portions of Marshall Ryegrass pasture (a) too early to begin grazing, and (b) right time to begin grazing.

Grazing when plants are too mature: Forages become more fibrous and less nutritious as they mature. Grazing animals select young shoots and leaves over mature stem when allowed to graze mature plants (Fig. 6.3a). As a result, most leaves and young shoot tips are removed and mature woody stems are left, especially when grazing with goats (Fig. 6.3b). This prevents vigorous regrowth and results in low productivity and quality.



Figure 6.3. Annual ryegrass pasture (a) became mature when not grazed on time, (b) goats selected leaves and young shoots and left fibrous stem when allowed to graze the mature ryegrass pasture, spring 2012, Phenix City, AL, USA.

Grazing perennial forages before they go dormant: Perennial forages produce biomass during their suitable growing seasons and remain dormant when the growing season ends. For example, tall fescue grows during spring and fall and remains dormant during the hot summer months. Similarly, warm season, perennial forages such as bahiagrass, dallisgrass, bermudagrass, and sericea lespedeza grow during the warm-season growing period (April to September/October), and become dormant during cool season (October/November to March). Forages need to have enough stored food before they go to dormancy for surviving while they are dormant and growing back vigorously in the next growing season. Therefore, grazing on these forages must stop four to six weeks before they become dormant. Otherwise, there will be limited or no stored food available for survival during dormancy and vigorous regrowth in the next growing season. As a result, some of the forage plants may die and surviving forages may have poor stand in the next growing season. Additionally, grazing animals must be taken off the pasture while forages are dormant unless there are other forages growing vigorously in the same pasture, such as in the case of mixed-species pastures.

Grazing during drought or adverse weather conditions: Young, growing plant tissues constitute 80 percent or more water. So, forage plants require enough moisture for vigorous growth. During drought condition, forage plants are stressed; they reduce or stop growing depending on the severity of the drought. Based on the condition of available forages during drought, grazing must be reduced or stopped completely and animals should be supplied with hay or other supplementary feedstuffs. When the drought condition is over and plants receive enough moisture for normal growth and development, the usual grazing schedule can resume. Similarly, in other adverse weather conditions such as flooding, stagnant water conditions, and extreme cold, forages stop growing or may die depending on the severity and duration of the adverse conditions. Under such situations, stocking rate and periods for resting and grazing should be adjusted so as not to hurt the forages and damage pasture.

Undergrazing: Undergrazing of pastures results from not putting enough animals in the pasture to achieve the desired level of forage defoliation, which is called understocking. When pastures are understocked, animals will have too much to select from. Consequently, animals will select

what they like the most and leave the less desirable ungrazed. This situation will favor less desirable forages to take over the pastures, while preferred species become scant or extinct. Additionally, much of the available forages are left unutilized, which results in low animal products per acre of pastures.

Overgrazing: Overgrazing is severe and repeated defoliation of forages accompanied with associated trampling. It results from stocking too many animals, exceeding the carrying capacity of the given pastures. Overgrazing results in various untoward effects on pasture plants and soils. Continued overgrazing of erect and semi-erect forage species generally weakens plants resulting in reduced root systems, lower forage yield, higher soil erosion and water run-off, and increased weed invasion. Also, there can be significant negative impacts of overgrazing on soil by contributing to soil compaction and creating smaller macroporosity, loss of pore continuity, greater bulk density, and pugging and puddling of soil when water content is high (Chen and Cui, 2001; Southorn and Cattle, 2004). Damaging effects of overgrazing on roots are discussed further in the following paragraph.

Root is very important for plant production as it absorbs water and mineral nutrients necessary for photosynthesis. Additionally, it serves as food storage for several plant species. Maintaining root mass and volume is important for maximum forage production. Defoliation hinders root growth and with severe defoliation, root mass and volume decrease. It is because when there is not enough leaf volume for photosynthesis and only little or no stored food is available to meet the plant demand, whatever food available from photosynthesis or storage has priority for shoot development. As a result, roots die back and only a limited amount of root volume is present in the shallow area. A deep and extended root system makes the plant able to access moisture and nutrients from deep and wide areas. So, a producer or a grazing manager needs to manage grazing (defoliation) so that root growth and development would not be hurt. Table 6.2 shows that 40 percent of the forage can be harvested without any detrimental effect on roots. When defoliation is increased from 40 to 50 percent, two to four percent root will stop growing; defoliation beyond 50 percent is very detrimental to root growth.

Root growth stoppage (%)
0
2-4
50
78
100

Table 6.2. Effect of defoliation on root growth.

Source: Dietz, 1989.

Stage for Hay Cutting

If there is extra forage available from grazing, one should consider harvesting it for hay and use it to supplement animals when there is not much forage available for grazing. Weather conditions and forage maturity determine the harvesting time. Dry and sunny days will allow forage drying in a short time and avoid loss due to rain and preserve quality. The aim of selecting the proper harvesting time is to maintain the highest quality in hay without compromising too much on quantity. Forage maturity suitable for hay cutting is shown in Table 6.3. If harvested earlier, there will be less dry matter and if delayed, the quality will deteriorate as forages mature. At harvest, green forage may contain 70 to 90 percent moisture, which has to be reduced to 15 to 20 percent for baling. Rapid drying is necessary since there will be a greater loss as drying time increases. If baled and stored without drying properly, hay can be moldy. After proper drying and baling, hay should be stored in a covered area with enough airflow so that it does not get wet, become moldy and rotten, and get heated to produce fire. The storage floor should be raised to about six inches or above with slatted wood, metal, or similar other materials to minimize hay damage that results from direct contact of hay with moist ground or soil.

Forage species	Time of harvest
Alfalfa	Bud stage for first cutting, one-tenth bloom for second and later cuttings. For spring seedlings, allow the first cutting to reach mid-bloom
Orchardgrass, timothy, or tall fescue	Boot to early head stage for first cut, then at 4 to 6 weeks intervals
Red, arrowleaf, or crimson clovers	Early bloom
Sericea lespedeza	Height of 15 to 18 inches
Oats, barley, or wheat	Boot to early head stage
Soybean	When pods are about half-filled and before bottom leaves begin to fall
Annual lespedeza	Early bloom and before bottom leaves begin to fall
White (or ladino) clover	Cut at correct stage of companion grasses
Hybrid bermudagrass	15 to 18-inch height for first cutting, then every four to five weeks or when 15 inches high
Birdsfoot trefoil	Bud to early bloom or at correct stage for companion grass
Sudangrass, sorghum-sudan hybrids, pearl millet	Height of 30-40 inches
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Table 6.3. Recommended maturity stage for harvesting hay crops.

Source: Ball et al., 2007.

Grazing Management

For pasture persistence and sustainability, one should select and implement a suitable grazing system or a combination of different grazing systems depending on the pasture situation, animals' nutrient requirements, and production target. As already mentioned, pastures containing only prostrate species, such as bahiagrass and bermudagrass, may be managed well with continuous grazing if the stocking rate matches well with the available forage biomass. On the other hand, mixed pastures require controlled grazing so that each forage species present in the pasture is utilized properly, but not overgrazed or undergrazed. Similarly, animals with higher

nutritional requirements and those susceptible to gastrointestinal parasites should get access to fresh pasture first followed by animals with lower nutritional requirements and those that have stronger immunity against parasites. One of the most common controlled grazing systems is a rotational grazing system. It is important to know the situations when rotational grazing is desirable over the continuous grazing.

Situations When Rotational Grazing is Superior to Continuous Grazing

- When pasture is not uniform in terms of quantity, quality, and composition, rotational grazing minimizes the selection. The chance of selection is high in a continuous grazing system, especially at a low stocking rate.
- When pasture needs to be irrigated, a rotational grazing system gives an opportunity to avoid the possible damage on soil and plants because of animals' action during and immediately after irrigation. Paddocks should be irrigated immediately after moving the animals out. In contrast, a continuous grazing system does not provide the facility of animal movement for pasture irrigation, so the damage to soil and pasture is imminent.
- When there is not much feed or forage available, ration feeding can be practiced in a rotational grazing system and a higher number of animals can be maintained for similar availability of forages as compared to the continuous grazing system.
- When running a dairy enterprise, more milk can be obtained from a rotational than continuous grazing system for two reasons. First, because of the establishment of social behavior in a rotational system due to splitting animals into smaller groups. Dairy animals in a small group feel happy and comfortable, and produce more milk (up to 20%) than when they are kept in a large group. Second, milking frequency can be increased as animals remain within a smaller grazing unit at a given time in a rotational grazing system. In this case, a producer can fetch the dairy animals to the milking parlor more easily than when they are scattered over a wide area as in a continuous system, and increase the daily milking frequency. Research has shown that increasing milking frequency from two to three per day increases milk production by 20 percent.
- When pasture species are susceptible to continuous grazing, like alfalfa, rotational grazing system should be practiced.

In other than the above situations, rotational grazing may not excel over the continuous grazing in an improved pasture with a proper herd management. Generally, for a lower stocking rate, continuous grazing is better than rotational grazing in terms of animal performance. It is because the quality of forages is likely to be lower at a low stocking rate since much of the forages are not harvested at the proper physiological stage, so they mature and the quality goes down. In such a situation, animals have access to a large area to pick up what they want in continuous grazing, but it is not so in a rotational grazing because they are confined to small grazing units. At medium stocking rate, animals perform similarly in both grazing systems. At a high stocking rate, rotational grazing is better. In this case, the quality of the pasture is the governing factor and the quality is higher under rotational stocking. In case of low quality pasture like bermudagrass and bahiagrass, rotational grazing is slightly better in terms of animal performance because forage quality is generally higher in rotational grazing as compared to continuous grazing. Nevertheless, one must not forget the higher input costs associated with a rotational grazing system as compared to a continuous grazing system. There are several things to be considered to establish and manage a rotational grazing system.

Establishment and Management of Rotational Grazing System

Pasture Subdivision

For a rotational grazing, a whole pasture area needs to be divided into smaller units, paddocks, so that animals can be moved from one paddock to another during a whole grazing season giving enough time for pasture re-growth in each paddock. Rotational grazing is based on the principle that pasture is benefited from a shorter grazing period and longer resting period. So, the number of paddocks should be decided based on the resting period required for the pasture re-growth. Usually, four to five paddocks, but not more than eight paddocks, will be enough. For four paddocks, there will be around a one-week grazing period and a three-week resting period for each paddock. Similarly, for eight paddocks, grazing period and resting period will be, respectively, of around four days and 28 days. In Figure 6.4, we can see that recovery period increases dramatically from zero to 15 days when pasture is divided into two paddocks, and becomes negligible after eight paddocks. Therefore, there is no need to have more than eight paddocks.



Number of paddocks

Figure 6.4. Grazing and recovery period for different numbers of paddocks in a rotational grazing with 30 days grazing. Source: Karki and Gurung, 2009.

Based on resting and grazing periods suitable for forage species, the number of paddocks required can be calculated as follows.

No. of paddocks required = (No. of days required for resting \div no. of days grazed) + 1

Suppose the resting period required is 28 days and grazing period is 4 days for each paddock at a time, then the number of paddocks required would be $28 \div 4 + 1 = 8$ paddocks.

While dividing pasture into paddocks, the following points should be taken under consideration:

- Each paddock should be uniform in terms of natural variation (quantity, quality, and composition of forages, shade, topography, access to water source, and soil quality) so that the selection of forage species as well as space is minimized.
- Gates should be placed in such a way to facilitate easy movement of animals while transferring them from one paddock to another.
- Water tank should be placed towards the center of the pasture so that animals from any portion of the paddock do not have to travel a long way to drink. It is a good idea to keep animals within 600 to 800 feet of the water source.
- Each paddock should be of similar size and production capacity and square shaped as much as possible.

Pasture Plantation and Grazing Schedule

Pasture can be planted at once or at different times to adjust with the animal movement in different paddocks. If planted once, animals should be allowed to graze the first paddock earlier than the optimum growth stage of the forage is reached, and move the animals faster to other paddocks so that the forage would not be overgrown and lower the quality in any of the paddocks. If animal grazing cannot catch up with the forage growth in all paddocks, few paddocks should be mowed to make hay or burnt and rotate animals in the remaining paddocks to maximize the forage utilization. If forage growth is faster, animals should be moved faster, and vice versa. One has to be flexible with animal movement frequency and sequence for the maximum utilization of pasture. If forages in different paddocks are sown at different times, manage the movement of animals to harvest the forages at optimum time, when the lowest leaves appear yellowing. Table 6.1 presents general guidelines on when to begin and end grazing various forage crops for proper pasture management. However, the resting period may vary depending on the stubble height – a longer resting period is required for shorter stubble height and vice versa for the same forage.

Forage Availability and Stocking Rate

The stocking rate should be adjusted based on the carrying capacity. The carrying capacity of a pasture indicates the number of animals the pasture can support to achieve a targeted performance for a specified period, which can be a grazing season or year after year, without detrimental effect on the pasture. Carrying capacity depends on the standing forage available for the grazing animals. When the growing condition is most favorable, forage production remains high and is able to provide adequate dry matter to support more animals. But under unfavorable conditions like limited moisture availability and other stressful conditions, production decreases

and would not support the same number of animals as under favorable production conditions. Therefore, the manager should adjust the stocking rate depending on the available forage. Understocking is the wastage of resources while overstocking is detrimental to pasture health and future production (Fig. 6.5).



Figure 6.5. Relationship between stocking rate and animal output (per animal and per acre). Source: Ball et al., 2007.

Generally, goats require two to six percent dry matter of their body weight depending on the physiological stage, productivity, live weight, and animal type (such as dairy, angora, meat) (NRC, 2007). For example, a mature, dry (maintenance only) meat doe weighing 110 lb requires dry matter two percent of her body weight; whereas, a mature lactating dairy goat with the same live weight and producing 15 to 21 lb milk requires more dry matter (6.07% of body weight). From the pasture yield estimation and animals' dry matter requirement data, the carrying capacity of a pasture can be estimated. Let's assume that a dry meat doe with 110 lb body weight requires dry matter 3.0 percent of her body weight, then she needs 3.3 lb (110 x 0.03 = 3.3) dry matter per day, which is equivalent to 11 lb green forage assuming that dry matter content of the available forage is 30 percent ($0.3 \times X = 3.3, X = 3.3/.3 = 11$ lb). One acre pasture with 1000 lb of available forage will support this doe for 90.91 days (1000/11 = 90.91). For grazing purposes, one should use the target stubble height while estimating the available forage mass (forages available above the target stubble should be accounted for). Supplying forages higher than animals' requirement is wasteful. Animals might eat more than their requirement if they have access, but utilization of the ingested forage decreases as the intake increases (Fig. 6.6).


Figure 6.6. Forage utilization decreases with the increase in intake; allowing more forage than required is wastage.

Source: Hodgson, 1990; NRCS, 1997.

Hands-on Activities

- 1. Calculation of number of paddocks for different species of forages.
- 2. Forage height measurement and calculation of available forages.

Key Points

- 1. Grazing should begin only when forages are well established and have achieved the grazing height, and grazing should stop when recommended stubble height is reached.
- 2. At least 50 percent of the leaf area of forages must be remaining intact with forage plants at the end of grazing in each grazing rotation.
- 3. Pasture containing mixed forage species or that with forages susceptible to continuous grazing must be managed with rotational grazing or other forms of controlled grazing.
- 4. A rotational grazing system provides a rest period, when pasture plants and soil get a chance to recover from the previous grazing pressure. A recovery period is not available with continuous grazing.
- 5. The stocking rate must be adjusted based on the available forage biomass, and overgrazing and undergrazing must be avoided.

References

- Ball, D. M., C. G. Hoveland, and G.D. Lacefield. 2007. Southern Forages. 4th ed. The International Plant Nutrition Institute (IPNI), Norcross, GA.
- Blaser, R. E. 1986. Forage-animal management systems. Virginia Agricultural Experiment Station Bulletin 86-7. Virginia Polytechnic Institute and State University, Blacksburg, VA.
- Dietz, H. E. 1989. Grass: The stockman's crop How to harvest more of it. Sunshine Unlimited, Inc., Lindsborg, KS.
- Karki, U. and N. K. Gurung. 2009. Year-round pasture production and management. Cooperative Extension Program, Tuskegee University, Publication No. TULV 0709-01 Livestock Production, p. 52.
- Hodgson, J. 1990. Grazing management: Science into practice Longman Scientific and Technical, New York, NY.
- NRC, National Research Council. 2007. Nutrient requirements of goat table. In: Nutrient requirements of small ruminants: sheep, goats, cervids, and new world camelids. The National Academies Press, Washington, DC. p. 271-299.

CHAPTER 7 PREDATOR MANAGEMENT

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Introduction

Many would say that the first line of defense for livestock is at the "life and limb" level. As hardy as most species of livestock are and as capable as they are relative to survival overall, they often cannot fend for themselves when it comes to attacks by predators that want to make them their next meal. They can run to try to escape but often cannot out-run a predator. The successful producer has faced this fact and has prepared for the eventuality that predation will sooner or later be a scenario that must be confronted.

This chapter will introduce important factors to consider in protecting livestock from predation and the management of existing predator problems (Cearley, 2007; Hygnstrom et al., 1994; Rollins et al., 2004). Some of these are: 1) animal husbandry methods that afford livestock protection; 2) infrastructure that denies predator access to livestock; 3) use of an Integrated Pest Management (IPM) philosophy and approach that applies non-lethal methods first, and lethal methods as required; 4) deliberate and dedicated use of critical thinking skills to accurately identify the cause of death of or injury to an animal; 5) acknowledgement that humane treatment should be utmost in the mind of a predator manager; 6) recognition that in this activity one has entered into an effort that truly is management rather than control—in other words one may never totally alleviate the problem, rather must learn how to cope with it to remain "in business"; and 7) appreciation for the fact that vigilance and perseverance are required long-term in order to provide the protection from predation that livestock need.

A Proactive Approach to Predator Management

Husbandry that protects livestock from predation to the greatest degree possible should be implemented first. Most areas of the United States have the potential for predator problems. Depending on the livestock type, various methods can be employed. Shed-kidding and shed-lambing, night penning, and herding can be used to provide protection for sheep and goats. Guard animals such as donkeys (Fig. 7.1), dogs, and llamas are particularly useful in many situations. Net-wire fencing with an apron (Fig. 7.2) or an overhead offset (Fig. 7.3) can discourage coyotes from digging under the fence and bobcats from climbing over. Likewise, two offset electrified wires (Fig. 7.4) can successfully fend off most climbing bobcats. Expanded descriptions of the use of the above measures, addressing individual problem species, are presented in the sections that follow.



Figure 7.1. Jennies guarding sheep in the Edwards Plateau of Texas.



Figure 7.2. Netwire fence with apron to deter passage of digging coyotes. Burying the apron increases its effectiveness. The apron should extend in the direction of predator approach. Photo by Dale Rollins.



Figure 7.3. Netwire fence with overhead lateral barbed wire extension to discourage climbing predators. The extension should point in the direction of predator approach. Photo by Dale Rollins.

Predator management



Figure 7.4. Offset electrified wires on an existing netwire fence can increase its effectiveness by discouraging predators from climbing.

Integrated Pest Management

Entomologists many years ago developed a driving philosophy for their work in protecting farm crops from insect damage. They gave it the name Integrated Pest Management. Strategies that stem from that philosophy are also useful for livestock producers who engage in activities to prevent or stop predation (Cearley, 2007).

The IPM concept is made up of five basic components:

- 1. Identifying pests versus beneficial organisms
- 2. Scouting population trends
- 3. Determining economic thresholds
- 4. Considering management alternatives
- 5. Weighing environmental concerns

Pests versus Beneficials

Being able to recognize whether a potential predator is detrimental (a pest) or beneficial to your operation is an important skill. Obviously, when a predator is killing livestock it has earned the name Pest. Wild animals which may serve as prey for predators can perform a valuable service as they provide a buffer for the effect on livestock that would be realized in their absence. Predators are generally opportunistic in their feeding habits. A density of rabbits and/or rodents providing a ready food source for predators which would otherwise be preying on livestock is a beneficial situation, lessening to some degree the amount of predation that might take place if rabbit numbers were low.

Likewise, situations can exist in which one potentially threatening predator population can control or limit the population density of another. If raccoons are the predator of concern, killing or maiming newborn kid goats, for example, coyotes can actually be beneficial to a degree because they are considered by many to limit raccoon numbers since they are a food source for coyotes. Far-fetched, certainly, since coyotes themselves are usually a threat to goat production. The point is, by lowering one population you may inadvertently enhance another which might also be damaging to your operation. The interrelationships of predators and their prey is a fascinating subject. An understanding of them is crucial to the realization of the desired results from your predator management efforts. An awareness of the complexities of these relationships should temper, to some degree, any tendency to oversimplify by carrying out a vendetta on all predators.

Scouting

Scouting refers to efforts to determine predator presence and their population levels. Records should be maintained through successive years to understand population trends. This information can aid in deciding whether or not to initiate a predator management program. Roads and sandy draws can be monitored for droppings (scats) and tracks. Look for scrapes where animals mark their territory. Net-wire fences provide the opportunity to check for hair left behind as animals cross over or under. Digs or slides under fences can be indicative of the passage of predators. Scent stations (Fig. 7.5) are made by clearing all of the vegetation off a portion of ground about one yard in diameter along a roadside. A generous dusting of a substrate such as flour or slacked lime and using an attractant like bobcat urine (available from trapping suppliers) placed on a cotton swab in the center, provides a means of discovering which predators are present in an area. Use the stations for at least three consecutive nights. Check for tracks the next morning after each night of use. Then refresh the surface with a dusting of flour or slacked lime to make it ready for the next night. Record the number of scent station nights on which the tracks of each species of interest appear.



Figure 7.5. Scent stations should be placed along roads for monitoring convenience and because predators often use roads for travel.

Predator population trends are important. If population density information is gathered the same way every season or year—using the same roads, the same methods, objectively - it will be useful for planning your predator management strategy. By keeping track (no pun intended) of the information gathered - the number of scats and/or sets of tracks on a given route which is monitored the same way every season or year, scent station nights in which various species occur, and accumulating the information over several years and across areas—you can begin to see what trend might be apparent in various predator populations and adjust your management accordingly.

Trouble spots might become evident as you monitor predator numbers. Whether by virtue of losses having occurred or the presence of an unusually high density of predators, you may choose to initially aim your efforts in those areas. You may also delay placing animals in a problem pasture or ranch until after the threat is reduced or eliminated.

Economic Thresholds

Economic feasibility understandably drives much of what is done in agricultural operations. Feasibility can be determined by identifying the economic threshold involved, specifically that point at which the level of damage incurred is sufficient to justify the cost of the control practice. Before undertaking any predator management activities, many of which can be rather expensive, be sure that the end justifies the means. It makes no sense to expend thousands of dollars to reduce losses amounting to hundreds of dollars unless there are long-term goals that justify the action. It is wise to utilize economically appropriate measures.

Considering Management Alternatives

Developing an array of management alternatives - a toolbox, so to speak - from which to select the appropriate approach to a particular situation, is another essential component of IPM. Both non-lethal and lethal techniques are available. Non-lethal means should be considered for use first, then lethal methods if necessary. Consider these examples of non-lethal measures (Cearley 2002, 2005, 2007; Rollins, 1997, 2000) that can be effective in many situations:

- 1. Shed lambing/kidding and/or year-round night penning for sheep and goats.
- 2. Use of guard animals such as donkeys, llamas, dogs, even ostriches. Some factors to keep in mind:
 - a. Match the guard animal species to the potential predator species. Donkeys and dogs, for example, are especially aggressive toward canine predators such as coyotes and feral dogs (domestic dogs either gone "permanently" wild or running in packs at night and sleeping on the owner's porch in the day).
 - b. Generally, guard animals should be raised with the animals they will be protecting, with no close contact with people. They must form a strong attachment behaviorally to their charges, ultimately developing a desire to ward off any threats. It is not uncommon for these characteristics to develop in a guard animal at a very early age.
 - c. Keep in mind the nutritional needs of the various choices in guard animals. Dogs must be fed daily. Donkeys and llamas can graze with the livestock, but care must be taken to provide adequate forage in the form of grass. Browse alone will not be adequate. During times of nutritional stress (drought, extreme cold, etc.) supplemental sources of energy and/or protein will be necessary.
 - d. Water sources should be maintained so that they are readily available and adequate in supply for the guard animals as well as the livestock they are protecting.
 - e. Plan to address the health needs of the guard animals, using the expertise of a local veterinarian who can recommend a health maintenance/disease prevention program that specifically fits your needs. All guard animals will need periodic examination and possibly treatment for external and internal parasites. Donkeys and llamas will likely require hoof trimming at times. Keep in mind that you will want to minimize handling of the guard animals as much as possible to keep the bond strong between them and the animals they are protecting.
 - f. Donkeys- Jennies (females) are preferred. They are aggressive protectors and are much less likely to kill calves, lambs, and kid goats than Jacks (males). Donkeys are preferred by many producers because, except for times of nutritional stress, feeding is not needed. They can consume the same forage as the other livestock.
 - g. Dogs- Several breeds are commonly used as guard animals. Among those are Great Pyrenees, Komondor, and Anatolian Shepherds. Other less common breeds are Akbash and Maremma. Personal preference, availability, and price are the primary factors involved in choosing which is best for your operation. Take into account the heat and cold-hardiness of the breed. Longer haired dogs, for

example, will likely be more lethargic and less effective in hot, humid weather. Neutered males and spayed females work best because they are not distracted from their duty during breeding season. You should be able to catch the guard dog for periodic inspection and veterinary care, but it should not want to follow you afterward. It should immediately want to return to the animals it is protecting.

- h. Llamas- Often praised, sometimes cussed, llamas can be effective as guard animals if used in the proper manner. The good ones can be very good: the bad ones can be dangerous to livestock and to people. Intact males, for example, will become protective of does during breeding season and become aggressive with people. To avoid llamas forming a group of their own and neglecting their duty, place only one llama with the herd and make sure it is out of earshot and sight of others of its kind.
- i. Dogs often work best in forested or otherwise dense vegetation because they depend on smell to identify predators. Donkeys and llamas tend to work best in more open situations where they can utilize their primary alert system, eyesight.
- j. Buy from a source that will work with you as you introduce the animal to its new surroundings and determine whether or not it will function acceptably. If it is not effective, take it back and try another. Particular species and breeds of animals make good guardians, but some individuals do not have the strong protective instinct that is required.
- k. Monitor the guard animal's behavior and measure its effectiveness by an observed reduction in predator losses. Judge whether the size of the herd(s) are conducive to protection by single guard animals. If there is doubt, add guard animals or reduce the size of individual guarded herds. Make certain that multiples of guard animals with a single herd are compatible with each other. Fighting and defending turf distracts from their assigned duty.
- 1. Pay attention to guard animal performance as they age. With lethargy in old age will come ineffectiveness as a guardian. Guard animal species and individuals within a species vary widely in length of useful service. Be ready to quickly replace any guard animal that is not doing its job, whether because of age, health, injury, or behavior.
- 3. Fencing type and configuration can limit predation, or at least provide for more effective application of some types of lethal techniques such as snares which can be placed in digs under net-wire fences. Net-wire fences are often used with sheep and goat operations. Many goat producers, for example, prefer small square mesh (4 inch by 4 inch) to lessen the possibility that goats will thrust their heads through the openings, entangling horns. Electrified offset (~8 inches) wires can be placed on fences at about 8 inches off the ground and again at about 30 inches to deter fence climbing by cats. Overhanging outward-leaning top portions of fences can also help. A buried lateral apron of net wire can deter digging under fences.

- 4. Noise-making devices, especially around pens where animals are kept overnight, can help ward off predators, though eventually the predators will likely grow accustomed to the sound and ignore it. Additionally, the noise could cause livestock stress and negatively affect their performance.
- 5. Aversive taste conditioning of predators has met with only limited success so far, but remains a possibility in the future.

If non-lethal practices are not feasible or effective, lethal measures (Cearley 2002, 2005, 2007; Rollins, 1997, 2000) might then be necessary.

Important Notice: Always check on regulations governing predator management in your local area. Laws vary significantly by municipality, county, and state. <u>Do not start any</u> <u>predator removal effort without a thorough understanding of the pertinent laws.</u> Then be careful to follow them as you proceed.

The toolbox most commonly includes:

- 1. Foothold or leghold traps- generally buried alongside travel-ways and baited with an attractant like a scat sprayed with predator urine (for coyotes and bobcats), and a visual lure like an over-hanging feather or tuft of hair (for bobcats), or blind-set in known paths; can be fairly selective (catching only target animals) depending on placement, bait, and overall operator skill.
- 2. Live traps or cage traps (Figs. 7.6, 7.7, and 7.8) fairly selective depending on size, bait, and trigger mechanism, but some predators, like coyotes, avoid them.
- 3. Snares (Fig. 7.9) suspended loops of cable with a one-way slide that tightens on the animal and restrains or kills it as it passes through; most often placed at a dig under a net-wire fence; selectivity depends on skillful placement in known passageways of offending animals and frequent monitoring.
- 4. Aerial gunning- effective and selective, approval and/or permit(s) required. <u>Check with</u> <u>your state wildlife officials for pertinent regulations and permits</u>. For further assistance contact USDA/APHIS Wildlife Services Office in your state (USDA-APHIS, 2012).
- 5. Calling- various manual or electronic audio devices which mimic the sound of a prey animal are used to lure predators within gunshot range.



Figure 7.6. Feral hog trap made of stock panel showing simple one-way entrance.



Figure 7.7. Live trap for feral hogs, using drop-type gate.



Figure 7.8. Rooter-type gate for feral hog trap (on display without remainder of trap).



Figure 7.9. Snare placed where predator has crawled under net-wire fence.

Environmental Concerns

An IPM approach always includes evaluation of potential environmental impacts. The manipulation of wildlife populations can involve numerous ramifications. Be aware of the effect that reducing the population density of one species may have on population levels of others. Lowering the numbers of coyotes for the sake of livestock protection, for example, may simultaneously enhance white-tailed deer survival and therefore their population density. Be prepared to harvest added numbers of deer if necessary in order to keep the population from exceeding the level that can be supported by the existing habitat without degradation.

Interpreting the Evidence

The basic skills needed to address suspected predation incidents (Cearley, 2007; Gallagher, 2009; Rollins et al., 2004) are similar to those required for a crime scene investigator. Among these are: an inquiring mind, critical thinking skills, knowledge of the habits of potential culprits, objectivity, and of course a strong stomach. Often a kill site is discovered well after decomposition has begun. Various "signs" can be sought out as evidence. The presence of tracks, scats, and hair left nearby (e.g., on fences) are telltale signs of visitation by a particular animal. However, generally more conclusive evidence is required to rule out whether that animal was just passing through or was indeed the perpetrator.

The mode of attack can be indicative of certain predators. Likewise the type and extent of damage suffered can point to one predator or another. For example, canine teeth spacing (Figs. 7.10 and 7.11) and corresponding puncture spacing on the hide, number of bites, location of damage (throat area vs. back of head or back), presence or absence of hemorrhage under the skin, and the location of the carcass and its general condition. If the carcass of a kid goat or lamb, for example, is found bearing soft hooves which appear never to have been walked on, there is a chance that the animal was still-born or died of neglect and subsequent exposure. Look for milk in the stomach to see if it ever nursed, and signs of dehydration such as sunken eyes. Also look for bites by skinning the throat area and the back of the neck or any other areas that appear to be affected. If there is an absence of hemorrhage under the skin, even if bite punctures are present, the animal was likely dead before being bitten. On the other hand if hemorrhage is present the animal was still alive when bitten, pointing toward predation.



Figure 7.10. Skulls of coyote (left) and bobcat (right).



Figure 7.11. Feral hog (young sow).

Common Culprits

Factors relevant to the objective scrutiny of livestock losses or damage (Cearley, 2007; Gallagher, 2009; Rollins et al., 2004) will be presented here for several of the common predators.

Coyotes



Figure 7.12. Coyote tracks.

Typically—and there are some exceptions as with all predators—a coyote (Fig. 7.12) will kill by attacking the throat region, biting and collapsing the trachea (windpipe) (Cearley, 2002; Rollins 1997). Death occurs by suffocation, sometimes after a rather prolonged struggle leaving considerable hemorrhage beneath the skin. Coyotes will at times bite the side of the head or even the back of the head. A young, inexperienced coyote may bite wherever it can catch the animal.

Eventually, with maturity, the throat attack seems to be the mode most often adopted. Coyote tracks (Figs. 7.13a and 7.13b) are rather slender and elongated. Particularly distinguishing characteristics include visible nail marks (often the middle two toes only) and bi-lobed heel pad. Their travel is usually deliberate, resulting in a straight path with hind feet often falling in the track of the front feet.

Scats (Fig. 7.13b) are usually cylindrical and cigar-shaped with minor strictures apparent and blunt or pointed ends. The texture varies according to the current diet, whether primarily vegetable (seeds evident in scat) or animal (hair and bone evident).

An integrated approach using a variety of control measures is most effective. Non-lethal measures include net-wire fencing and guard animals. Also consider trapping (No. 4 with chain and drag hook), snaring, aerial hunting, and calling. Be careful to avoid "educating" coyotes with unsuccessful attempts at trapping, snaring, or calling, especially. Coyotes are intelligent animals that become more wary of management attempts with each failure—often to the point of being almost impossible to catch. Make your first "shot" count.





Figure 7.13. Coyote track (a), and coyote scat and tracks (at arrows) (b).

Bobcat



Figure 7.14. Bobcat tracks.

Bobcats (Fig. 7.14), with few exceptions, attack by biting the back of the neck at the base of the skull or on the side of the head (Rollins, 2000). Or they may bite the back of the jaw and lower part of the skull, while restraining by embedding their claws in the prey's side or flank. Death is usually caused by crushing the spine and/or skull. After the kill the carcass may be fed upon immediately or it may be cached—dragged to another location and partially covered with debris—to be fed upon later (Fig. 7.15). If the meat spoils before consumption it may be abandoned for another fresher kill. Often hair will be plucked from the carcass in a few spots, giving it a scruffy appearance (Fig. 7.16).

Tracks (Fig. 7.17) are more rounded in appearance than those of a coyote, and are larger. Nail marks are usually not apparent since cats typically keep claws retracted until needed for defense or capture of prey. The heel pad is tri-lobed (Fig. 7.18). On especially soft surfaces the track may appear to be "tented" or "peaked" between the toes, owing to the shorter hair between them compared to coyotes.

Bobcat scats (Fig. 7.19) are cylindrical and are segmented with prominent strictures and usually have elongated pointed ends, often with protruding hair on the end last expelled. Non-lethal methods include electrified offset wires on fences and fence over-hangs, both to deter climbing. Cage traps have been successfully used with a rear, protected compartment containing a live chicken to serve as a visual, audible, and scent lure.

Previously mentioned lethal means are effective for bobcats also. Possibly owing to their innate curiosity, bobcats are usually more readily trapped than coyotes.



Figure 7.15. White-tailed doe killed and cached by bobcat. Note debris partially covering carcass. Photo by W. Klussman.



Figure 7.16. White-tailed deer killed by bobcat. Note areas which have been plucked of hair and left scruffy in appearance. Photo by W. Klussman.



Figure 7.17. Bobcat tracks. Typically claw marks are absent.



Figure 7.18. Front and rear feet of bobcat. Note tri-lobed rear portion of heel pads.



Figure 7.19. Bobcat scat. Note faint track at arrow.

Red Fox



Figure 7.20. Red fox tracks.

The red fox (Fig. 7.20) is an introduced species that is often confused with the smaller gray fox, and is responsible for livestock losses in some locales (Cearley, 2007; Rollins et al., 2004). The red fox's white-tipped tail is a distinguishing characteristic. Tracks are coyote-like, though smaller. Marks from all four claws on each foot are likely to be visible. Scats are generally non-segmented, bearing pointed ends with protruding hair. Predation is typically characterized by multiple bites on the back of the prey animal. Due to the relatively small size of red foxes, young animals such as kid goats and lambs are most vulnerable to red fox predation. For control consider trapping, snaring, and hunting. Red foxes can often be called up with the use of preymimicking audio devices (calls).

Feral Hog



Figure 7.21. Feral hog track.

To date, well over 30 states in the U.S. have reported the presence of feral hogs (Fig. 7.21) - hogs which are either domestic hogs gone wild or descendants of free-roaming hogs first brought to North America by early explorers centuries ago (Cearley, 2005; CFH, 2012; FHCP, 2012). Livestock predation is one of the many negative impacts they have caused. Young animals such as lambs and kid goats are particularly vulnerable. Calves are also known to fall prey to feral hogs.

Often no evidence of predation is found when feral hogs are the culprit because the entire prey animal is consumed. A bloody patch of ground, a hoof or two, or an inverted skin with hooves and maybe the skull attached, is likely to be all that remains. Sometimes the only indication may be circumstantial—missing young, dams with distended udders, and the known presence of feral hogs in the area.

Signs of their presence include: rubs on trees and utility poles (Fig. 7.22), wallows in mud (Figs. 7.22 and 7.23), and rooted-up soil, rocks, and debris (Fig. 7.24) where they have searched for food items. Being a cloven-footed animal, their tracks (Fig. 7.25) are similar to deer and goats, but with more blunt tips, and dewclaw marks are often present. Scats (Fig. 7.26) are large and resemble a pile more often than a cylindrical mass, especially when fruits and other plant items are being consumed.

Aerial hunting, where laws and the terrain and vegetation allow, is the most efficient and cost effective control means for feral hogs. Portable cage traps or funnel traps built on-site with t-posts and welded wire hog panels are the second most effective means of removal. With either trap setup use a one-way gate and pre-bait the trap with the gate open for several days until hogs grow accustomed to entry, then set for capture.



Figure 7.22. Feral hog wallow and rub on utility pole. Feral hogs seem to have an affinity for creosote.



Figure 7.23. Feral hog wallow.



Figure 7.24. Evidence of rooting activity by feral hogs in sandy loam soil.



Figure 7.25. Feral hog tracks.



Figure 7.26. Feral hog scat.

Domestic and Feral Dogs



Figure 7.27. Domestic and feral dog tracks.

Though wild predators garner more of the immediate attention when livestock predation is known or suspected, free-roaming domestic dogs (Fig. 7.27), some of which are more accurately described as wild or feral, are serious contenders for the top spot on the list of suspects (Cearley 2007; ICWDM, 2012; Rollins et al., 2004). Breeds vary extensively in size and conformation, so track evidence is highly variable and often resembles wild canines or cats. Like coyotes, domestic canines have bi-lobed heel pads but typically have a more sloppily-placed print, i.e. dogs are less likely to be deliberate straight-line travelers than coyotes. Kills by dogs are often characterized by multiple bites on the hind quarters and flaps of skin pulled away from the animal due to the dog's attempts to restrain the fleeing prey. Several animals might be attacked at once by a single dog or a pack of dogs, sometimes with little, if any, feeding on the carcasses. Check local regulations governing predation by dogs before attempting any control measures. The same methods used for coyote control can be effective for domestic dogs, but the laws regulating their take, if allowed at all, can be quite different.

Black Vultures

Both turkey vultures (red head) and black vultures (grey head) (Fig. 7.28) feed on carrion, or dead animals. Black vultures, however, are known to attack and kill calves, lambs, goats, piglets, and other relatively weak animals, especially the newborn (Hygnstrom et al., 1994; ICWDM, 2012; Rollins et al., 2004). They target the eyes and other soft membranous tissue, killing the prey or often causing so much injury that the animal must be euthanized.



Figure 7.28. Black vultures are known to feed on newborn livestock and other relatively weak animals, causing mortal injury.

Vultures are migratory birds that are protected by the Migratory Bird Treaty Act and state laws and regulations. The US Department of the Interior's Fish and Wildlife Service is responsible for their management. Without a Migratory Bird Depredation Permit the birds, their nests, and eggs cannot be killed or destroyed. Contact your USDA- APHIS Wildlife Services state office for specific local information (USDA-APHIS, 2012).

Hands-On Activities

- Snare-setting
- Trap-setting
- Scent Station/Game Camera installation

Key Points

- 1. Predator management is a crucial component of successful livestock production. Specific action may or may not be necessary in your particular locale. Constant vigilance, however, and pre-emptive measures such as husbandry methods aimed at livestock protection, guard animals, and proper fencing can pay significant dividends. These can address predation at first appearance, before it grows to a much larger problem that is more difficult to control.
- 2. When considering a predator management effort, always use an Integrated Pest Management approach: 1) identify pests versus beneficial organisms; 2) scout population trends; 3) determine economic thresholds; 4) consider management alternatives; and 5) weigh environmental concerns.
- 3. Make it a habit to regularly consult the myriad of constantly updated resources available for predator management advice and recommendations, such as the Internet Center for Wildlife Damage Management (ICWDM, 2012), USDA-APHIS Wildlife Services (USDA-APHIS, 2012), Feral Hog Community of Practice (FHCP, 2012), and the Texas A&M AgriLife Extension Bookstore (TAMAEB, 2012).
- 4. Above all, <u>consult your local wildlife regulatory agency before you begin any predator</u> <u>management effort</u>. Learn which animals are protected in your area. Make sure you comply with licensing as applicable, laws pertaining to legal means and season of take, and all other regulations in place.

References

- Cearley, K. A. 2002. Coping with Coyotes. VHS video. 29 min. Sheep and Goat Predator Management Board, San Angelo, TX.
- Cearley, K. A. 2005. Coping with Feral Hogs. DVD and VHS video. 32 min. Texas A&M AgriLife Extension Service. SP-210 and SP-209. Accessed Sept. 1, 2012. http://agrilifebookstore.org/.
- Cearley, K. A. 2007. Predator Management for Goat Producers. In : T. Gipson, editor, Meat Goat Production Handbook. Langston University, Langston, OK. p. 267-278.
- CFH. 2012. Coping with Feral Hogs. Texas A&M AgriLife Extension Service, Department of Wildlife and Fisheries Sciences. Accessed Sept. 1, 2012. http://feralhogs.tamu.edu/.

- FHCP. 2012. Feral Hog Community of Practice. Cooperative Extension Program, Texas A&M AgriLife Extension Service. Accessed Sept. 10, 2012. <u>http://www.extension.org/feral_hogs</u>.
- Gallagher, J. 2009. Procedures for Evaluating Predation on Livestock and Wildlife. Bull. No. B-1429. Texas A&M AgriLife Extension Service, College Station.
- ICWDM. 2012. Internet Center for Wildlife Damage Management. Research-based Wildlife Control and Management Information from Experts Who Care. Accessed Sept. 10, 2012. http://icwdm.org/.
- Rollins, D. 1997. Coping with Coyotes. Bull. No. B-1664. Texas A&M AgriLife Extension Service, College Station.
- Rollins, D. 2000. Coping with Bobcats. VHS video. 23 min. Sheep and Goat Predator Management Board, San Angelo, TX.
- Rollins, D., J. Brooks, R. Eldridge, M. Mapston, J. Allen, R. Kott, M. McDougall, R. B. Taylor, K. Cearley, D. Brandenberger, and A. Gilliat. 2004. Predator Control as a Tool in Wildlife Management. Bull. No. B-6146. Texas A&M AgriLife Extension Service, College Station.
- Hygnstrom, S. E., R. M. Timm, G. E. Larson, editors. 1994. Prevention and Control of Wildlife Damage. University of Nebraska, Lincoln.
- TAMAEB. 2012. Texas A&M AgriLife Extension Bookstore. Accessed Sept. 1, 2012. https://agrilifebookstore.org/.
- USDA-APHIS. 2012. Wildlife Services. United States Department of Agriculture- Animal and Plant Health Inspection Service. Accessed Oct. 30, 2012. <u>http://www.aphis.usda.gov/</u>wildlife_damage/.

Animal track drawings courtesy of D. Rollins.

Photos by Ken Cearley except where noted otherwise.

CHAPTER 8 DISASTER PREPAREDNESS FOR LIVESTOCK AND DEALING WITH DISASTER AFTERMATH

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Introduction

Natural disasters and widespread disease can be devastating to livestock producers. Hurricanes and flooding, wildfire, winter storms and extreme cold, tornadoes, lightning, drought, and epidemics and biosecurity are some of the most devastating occurrences with which livestock producers may have to contend (Bivens, 2007). Deliberate measures to prepare for such events in order to mitigate their impacts should be a management strategy that receives the highest level of priority.

Hurricanes/Flooding

Preparing for a hurricane and/or flooding (Paschal, 2012)

- Make sure vaccinations for diseases such as blackleg, leptospirosis, tetanus, and encephalitis are current for all livestock.
- Lay-up extra feed, hay, and water supplies.
- Have basic veterinary supplies on hand (bandages, topical antibiotics, tetanus toxoid).
- Have restraint equipment handy (ropes, halters) and ready for use with injured animals that need assistance.
- Make sure there are no loose boards, roofing material, etc. on buildings. Pick up debris and other loose items around pens and pastures that could become airborne in high wind and injure livestock. Most injury to livestock comes from wind and flying debris.
- Strap-down barns and sheds to ground ties. Place equipment under cover if possible. Just before land-fall, turn off electrical supplies to all facilities except electric fences.
- If possible, evacuate livestock from the threatened area to large pastures on high ground and some form of shelter such as brush or trees. Never leave livestock in a closed barn. Building damage could harm the livestock inside. Turning livestock loose is better than leaving them in small pens or barns. Evacuating them is best.
- Protect feed and hay from wind and water. Hay bales should be on high ground or stacked on posts or tires. Cover bales if possible to avoid water damage.
- Maintain a complete and accurate inventory of all livestock, including information such as sex, age, identification numbers, and brands.

Specific steps after a hurricane and/or flooding (TEDEN, 2012a)

- Livestock face danger of drowning from flooding and from flying debris or collapsing buildings during and after hurricanes. Watch for downed power lines that can present electrocution hazards. Check fences along roads for downed trees or open water gaps. Livestock seeking high ground during the flooding aftermath of a hurricane often move onto roadways and create dangerous hazards to motorists.
- Use extreme caution when entering hurricane-affected areas. Be careful around debris and watch for chemical spills, downed power lines, and other hazards. Move livestock out of flooded areas and to dry ground as soon as possible.
- Watch for snakes as they seek higher ground, especially rattlesnakes, water moccasins, and copperheads. Coral snakes are a lesser problem since they cannot envenomate as quickly, but still warrant extreme caution. Most bites occur on the face or neck of livestock, potentially causing swollen, blocked airways, leading to asphyxiation if left untreated. The smaller the animal, the greater and more immediate is the problem. Contact a veterinarian quickly for treatment.
- Mosquitoes can be a major problem. Foggers and sprays are available for small areas. For larger livestock and larger areas the only practical immediate relief is dry pasture with a good wind. West Nile virus can be transmitted by mosquitoes and is a serious threat to horses. The best defense is vaccination.
- Ticks will be moving to high ground and onto livestock and can transmit diseases like anaplasmosis. Infestations can be treated with commercial products.
- Monitor water quality, especially where livestock inhabit areas with streams, bayous, tanks, or ponds that fill with rain runoff. Contaminants such as salt water from storm surges, petroleum products, dead animals, and fecal material from flooded septic and sewer systems may be present. Provide the cleanest water possible until water sources can be evaluated.
- Dispose of dead animals promptly and properly. Check with local authorities about laws that regulate how this task should be accomplished.

Wildfire

Protection from wildfire

- Wildfire is a threat on grazing lands whenever there is an abundance of fine fuel (grass), dry conditions, and an ignition source. Whether accidentally set, naturally set by lightning, or intentionally set, fire, apart from a prescribed application under specific, suitable, and safe conditions, can be devastating in its effects. Fireguards in the form of permanent, temporary, or green firebreaks are the best defense against loss of forage, structures, livestock, and human life to wildfires (Hanselka, 2012; Ledbetter et al, 2011; TEDEN, 2012b). These should be prepared well in advance of anticipated high risk periods such as drought.
- Permanent firebreaks are cleared of vegetation down to mineral soil. They can take the form of disked lanes made by mowing, followed by disking repeatedly until no continuous fuel bridge remains across the guard. Plowed firebreaks can be created even

in tall or heavy grass fuels by mowing, followed by scraping or blading with a dozer or grader. Be careful not to leave piles of grass near the fire line. Pasture roads serve well as firebreaks. Mow grass growing between wheel ruts. Public roads work well, but be mindful that the vegetation in the drainage ditches provides ignition points, lessening the value of the road for a firebreak unless it has significant width. Rivers, creeks, lakes, and cultivated fields provide natural firebreaks.

- Temporary firebreaks include mowed fire guards, blacklines, wet lines, and chemical firebreaks. Mowed fireguards reduce the amount of tall standing fuel but do not eliminate the possibility of fire spreading. Fire is only slowed by this type of firebreak, making the fire somewhat easier to extinguish. Blacklines, or burned firebreaks, are created by burning out fireguards under safe conditions. Both mowed and burned firebreaks demand regular maintenance. They should be wide enough to prevent the travel of burning embers across the guard. Pine leaf litter is a special concern since fire can creep across a fireguard with this volatile fuel in place. Be sure to check with local authorities about laws pertaining to burning in your area. Acquire adequate training for the safe, legal, and effective use of fire.
- Wetlines, using water to wet down adjacent fuel while a blackline is being put in place, is another type of temporary fireguard. Chemical fireguards are created by the application of a super phosphate to the fuel, raising its ignition temperature.
- Protection from slow moving fires can be gained through the use of green firebreaks that provide the added benefit of winter grazing for livestock and wildlife. Disked lines are fertilized and seeded with cool season annuals which will be in place during the winter when many fires occur. The lines must be prepared and re-planted annually.
- Fireguards must obviously be wide enough to hinder the passage of a fire. A good rule of thumb is that the firebreak should be at least three times as wide as the height of adjacent vegetation. In some situations it should be considerably wider. Fireguards should be wide enough to take into account the wind strength common in your area and the potential for airborne burning embers. The minimum recommended width for a blackline is usually 100 feet for low volatile grass fuels and 500 feet for windrowed brush or volatile fuels like junipers (cedars).
- For best results, use more than one type of firebreak. For example, mow both sides of a disked line.
- <u>Never attempt to burn without adherence to all applicable laws and regulations</u>. And, <u>never attempt to burn without adequate training and experience</u>.
- Have an animal evacuation plan in place and implement it ahead of a wildfire. Move livestock away from the fire danger zone and away from the area downwind that will likely be receiving smoke. Attempt to minimize the risk of smoke inhalation by livestock. Open gates and cut fences as needed to be able to move animals quickly. Load into trailers and haul to a safe location if time allows.

After a wildfire

- To minimize livestock losses after a wildfire immediately inspect all surviving animals that have been exposed to fire and smoke. Common disorders include burned eyes, feet, udders, sheaths, and testicles. Smoke inhalation can cause lung inflammation and edema, and is the most common problem. Be sure to consult with a veterinarian to decide whether affected animals should be treated, sold to slaughter before secondary infection sets in, or humanely euthanized and disposed of, using a lawful method (Ledbetter et al., 2011; TEDEN, 2012b).
- Some problems will not be noticed for as long as 10 to 14 days, so monitor the condition of animals extra closely during this time. Watch for symptoms such as coughing, cloudy eyes, lameness, and irritation of eyelids and eyeballs. Cattle that sustained burns on the coronary band above the hoof may start sloughing the hoof wall eventually and develop secondary infections. Lameness usually ensues and will require immediate attention by a veterinarian.

Winter Storms/Extreme Cold

Preparing for a winter storm or an extreme cold spell

Minimizing exposure to wind and moisture to the extent possible is essential in the thermal protection of all classes of livestock, whether cows or horses or sheep or goats, when extreme cold sets in. In preparation for extreme cold weather, provide man-made wind breaks or brushy or forested portions of a grazing unit (pasture). These refuges will offer a degree of shelter that will be sought by livestock when temperatures drop drastically (Machen, 2011a).

When a winter storm or an extreme cold spell arrives

- When the winter storm arrives, keep in mind that the winter haircoat of most livestock will adequately protect them if they can find protection from the wind. However, a wet haircoat loses its natural insulation value and allows animals to rapidly lose body heat. If possible, provide shelter from moisture. Young animals in thin flesh and newborns lack enough fat under the skin to provide insulation. Make a special effort to provide shelter for these vulnerable animals (Machen, 2011b).
- Hay should be provided if forage is short. Digestion generates heat so feed late in the day to maximize the benefit during the coldest hours, typically during the night.
- Feed horses twice per day and exercise them, even if only 30 minutes in the barn or in an outside paddock. Colic can be a problem for horses in the winter, to a lesser degree for those on pasture than those in stalls. For prevention, feed extra, long-stem hay and make sure horses receive adequate amounts of water. Adult horses will drink 10 or more gallons per day.
- Water intake is critical for proper digestion of all livestock classes. Break and remove ice from water sources. Feed livestock near water to encourage consumption. Keep in mind that restricted water consumption can reduce feed intake. Adequate feed intake is crucial for the heat generation that digestion provides.

Tornadoes

- Many times accompanied by hail and heavy rainfall, tornadoes are responsible for extensive damage and destruction. Tornadoes most often occur in the month of April in the U.S., but can develop any time warm moist air is forced upward by afternoon heating of the ground or an advancing cold front (Bivens, 2007).
- Except for awareness of conditions that are conducive to the formation of tornadoes, and being ready to provide immediate protection for human life, little can be done to protect livestock from the effects of a tornado. Tornadoes often happen with little or no warning and usually do not allow for preparatory measures aimed at saving livestock.
- After the storm has passed, be prepared to contain animals by repairing fences and/or providing temporary fencing. Watch for downed power lines and stay out of damaged structures that may collapse. Inspect all surviving livestock for injuries and consult a veterinarian for any treatment that you cannot provide. Keep in mind that their services will be in great demand, so call your veterinarian only after you see that emergency attention is needed that you cannot provide on a temporary basis.

Lightning

Up to 80 percent of livestock loss to accidents is attributable to lightning, including direct strikes and fires caused by lightning. Prevention of losses from lightning can be achieved by the following (Bivens, 2007):

- Install at least two grounds on all buildings.
- Ground wire fences (not necessary for electric fences—they are already grounded).
- Install lightning rods on all silos and other high structures close to livestock activities.
- Make sure lightning arrestors are on all overhead wires.
- Where feasible, bury utility lines, including electrical and phone.
- Ground dog run wires.
- Ground especially vulnerable and valuable trees with a lightning rod installed at the tree's highest point.
- Build fences at the drip line of lone trees in the open that are especially susceptible to lightning strikes, to keep livestock from congregating under them during thunderstorms.
- Avoid metal chains for animal leads or tethers, and metal chains on animals left in the open.

Drought

• Reliability of efforts to predict the onset of drought conditions has been significantly enhanced by the use of information available from the National Weather Service's National Oceanic and Atmospheric Administration Climate Prediction Center (NWS, 2012). Armed with the data it provides relative to El Niño/La Niña conditions, producers can be much more confident in their actions relative to likely long-term weather conditions. Operational adjustments are best made with long-time horizons in mind, not the most immediate weather forecasts and most current rainfall or lack thereof.

- The best protection from the harm that a drought can cause, both economically and from a land management standpoint, is proper stocking density. If high value animals make up the entire herd it is much more difficult to cull numbers in the face of increasing drought conditions to match available forage. Consider maintaining a "permanent herd" that makes up around half of the carrying capacity for your land—the number that can be maintained year-to-year without overusing the resource and causing a change in the plant community to one that is less productive. The other half could be made up of lesser value animals—animals that could more easily be sold as needed to maintain proper stocking as conditions decline.
- Whether you are a lessor or lessee, strive for contractual arrangements that allow payments on a per-head per month basis. This will mitigate the impact of advancing drought and declining forage conditions. Lessors stand to receive a somewhat lesser income in drought periods when compared to contracts that require annual payments. But, lessees have the flexibility to reduce numbers as conditions dictate, without jeopardizing the ability to meet a fixed annual payment. The benefit to the lessor is the potential for much better land stewardship and a satisfactory long-term business relationship with the lessee.

Epidemics and Biosecurity

Possibly the most dreaded of all disasters to livestock producers is the appearance of a rapid onset, highly contagious foreign animal disease that not only poses an immediate threat but also threatens the livestock industry as a whole and countless associated livelihoods. Whole herds can be decimated either by the effects of the disease or through euthanizing to prevent spread of the disease. Foot and mouth disease, vesicular stomatitis, and bovine spongiform encephalopathy are among the many viral and bacterial menaces that exist (Dement et al., 2008).

Constant monitoring of foreign animal diseases is provided by the USDA Plum Island Animal Disease Center by scientists and veterinarians with the Agricultural Research Service and the Animal and Plant Health Inspection Service headed by the Department of Homeland Security. Early detection methods are constantly being sought and applied to thwart agro-terrorism efforts that would threaten America's food supply.

The primary means of preventing an epidemic include the following:

- Buy only from reputable producers who have known healthy herds.
- Use extreme caution when importing animals from foreign countries.
- Close your herd as soon as possible.
- Report any unusual health problems to your veterinarian immediately.

Key Points

- 1. As soon as it is safe to do so after a natural disaster, check on the condition of fences, pens, barns, and sheds. Check pastures for debris. Move animals to safe areas.
- 2. Give stressed animals clean feed or hay and water. If any animals have not had access to feed for a day or more, give them a small amount of feed for the first few days. Gradually increase feed daily until reaching full feeding level by the end of a week. Give

animals access to clean hay even if it is wet. But, <u>do not give moldy hay to livestock.</u> Dry feed is preferred for all classes of livestock. If you need hay, contact your county Extension agent for a list of suppliers.

- 3. Watch for signs of sickness. Pneumonia can develop in animals that have been subjected to water and cold for extended periods of time. Be vigilant for coughing, runny noses, crusty eyes, hard breathing, and lowered heads. Provide or seek treatment as soon as possible.
- 4. Check for injury. Contact a veterinarian for serious injuries, if necessary. Remember that the veterinarian may have a family and property that was affected also. When you call, be precise in describing the injury. Provide respiration rate, temperature, and pulse rate. Tell exactly where the animals are located and be sure to inform the veterinarian of any road or bridge closures on the way. Offer to provide the treatment or aid suggested. He or she may have more urgent cases to take care of first.
- 5. For help in rescuing livestock or assistance in burying carcasses, contact your county emergency management department or county Extension agent.
- 6. The stress of bad weather can cause heavy bred females to give birth. Watch for newborns.
- 7. Report missing livestock to your county emergency management office. Make sure to tag your animals so that you can report with the identification.
- 8. Document and report livestock losses to the county Farm Service Agency (FSA). To locate the phone number, go to <u>http://www.fsa.usda.gov/</u>.
- 9. For information about composting carcasses, consult your county Extension agent or Auvermann et al. (2006).

References

- Auvermann, B. S. Mukhtar, and K. Heflin. 2006. Composting large animal carcasses. Bull. No. E-422. Texas A&M AgriLife Extension Service, Amarillo. Accessed Oct. 31, 2012. http://amarillo-tamu-edu.wpengine.netdna-cdn.com/files/2011/01/e422_03.pdf.
- Bivens, D. 2007. Disaster preparedness for livestock. Web-based Training and Certification Program for Meat Goat Producers, Langston University, Langston, OK. Accessed Feb. 9, 2013. <u>http://www.luresext.edu/ goats/training/disaster.html</u>.
- Dement, A., T. Antilley, S. Hammack, J. Cleere, E. Jordan, B. Craddock, J. Paschal, B. Dominquez, B. Scott, M. Farnell, J. Sterle, and F. Faries, Jr. 2008. General biosecurity for livestock and poultry producers. Bull. B-6199, Texas A&M AgriLife Extension Service, College Station. Accessed Oct. 31, 2012. <u>http://fazd.tamu.edu/files/2012/ 02/B6199_1.pdf</u>.
- Hanselka, C. 2012. Protection of Rangeland and Pastures from Wildfire. Texas Extension Disaster Education Network, Texas A&M AgriLife Extension Service, Corpus Christi, TX. Accessed Sept. 10, 2012. <u>http://texaseden.org/disaster-resources/wpcontent/uploads/2010/09/protection-of-rangeland-and-pastures-from-wildfire.pdf</u>.
- Ledbetter, K., F. Faries, T. McCollum, and R. Gill. 2011. Early detection of fire damage can minimize cattle losses due to fire. Texas Extension Disaster Education Network, Texas

A&M AgriLife Extension Service. Accessed Sept. 11, 2012. <u>http://texaseden.org/</u> <u>disaster-resources/wp-content/uploads/2011/03/Early-Detection-of-Fire-Damage-Can-</u> <u>Minimize-Cattle-Losses-Due-to-Fire.pdf</u>.

- Machen, R. 2011a. Cold Weather Livestock Stewardship. Texas Extension Disaster Education Network, Texas A&M AgriLife Extension Service. Accessed Sept. 1, 2012. <u>http://texaseden.org/disaster-resources/wp-content/uploads/2011/05/Cold-Weather-Livestock-Stewardship.pdf</u>.
- Machen, R. 2011b. Tending Cattle after the Winter Storm. Texas Extension Disaster Education Network, Texas A&M AgriLife Extension Service. Accessed Sept. 1, 2012. <u>http://texaseden.org/disaster-resources/wp-content/uploads/2011/05/Tending-Cattle-after-the-Storm.pdf</u>.
- NWS. 2012. El Niño/La Niña. National Weather Service, National Oceanic and Atmospheric Administration, Climate Prediction Center. Accessed Sept. 12, 2012. http://www.cpc.ncep.noaa.gov/products/precip/CWlink/MJO/enso.shtml.
- Paschal, J. 2012. Hurricane Preparedness for Livestock Producers. Texas Extension Disaster Education Network, Texas A&M AgriLife Extension Service. Accessed Sept. 10, 2012. <u>http://www.smashwords.com/books/view/150562</u>.
- TEDEN. 2012a. Care and Treatment of Livestock after a Hurricane. Texas Extension Disaster Education Network, Texas A&M AgriLife Extension Service. Accessed Sept. 10, 2012. <u>http://texashelp.tamu.edu/005-agriculture/pdf/care-and-treatment-of-livestock-after-a-hurricane.pdf.</u>
- TEDEN. 2012b. After a Wildfire: Checklist of Considerations for Post-Fire Management. Texas Extension Disaster Education Network, Texas A&M AgriLife Extension Service. Accessed Sept. 10, 2012. <u>http://texashelp.tamu.edu/004-natural/pdfs/checklist-of-considerations-for-post-wildfire-management.pdf</u>.

CHAPTER 9 IDENTIFICATION AND MANAGEMENT OF DIFFERENT BROWSE SPECIES ADAPTED TO THE SOUTHERN REGION

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Introduction

Goats are classified as opportunistic generalists, capable of seeking out and consuming the best quality forage available, whether it is herbage (grass), forbs (broadleaf weeds), or browse (leaf and twig growth of woody species). They are healthier and do better when their diet is comprised of predominantly browse. As summarized by Maurice Shelton (personal communication), "The only reason God made a goat was to eat brush." Browse tends to be higher in protein and minerals than other forms of forage. Because they typically have deeper roots, woody species are thought to be better at extracting minerals from deeper levels in the soil where they have not been depleted. Goats have a strong preference for browse, although if available, their diet will also include a significant portion of herbage and forbs. Goats will be healthier if they have access to significant browse, especially if there is a diversity of browse species. The higher protein content of browse and the fact that goats spend less time grazing close to the ground where infective larvae of goat parasites are located, promote goat health and well-being.

Identification of Various Browse Species Adapted to the Southern Region

Generally, goats have been used for hundreds of years to control browse species. Browse species are typically poorly adapted to defoliation and many of them have antinutritive factors and/or physical defenses to protect them from defoliation. Goats generally can consume most browse species and if allowed to do it at will, the result will be a reduction in vigor of the woody species. Sequential defoliation during the season or over years often results in death of the woody plant providing control of browse species. Therefore, goats are useful for controlling woody species and to a lesser extent, forbs because they readily defoliate these species.

We use the term biodiversity as a measure of the number of different forage species in the ecosystem. Benefits of biodiversity include resistance to invasion by plant species and insects, reduced spread of plant diseases, and increased yield and yield stability over time (Tilman, 1999). Often, the objective of vegetation management is to restore biodiversity by controlling dominating, often invasive species, thereby increasing the number of contributing species in an ecosystem. This will also have beneficial effects on the biodiversity of vertebrates and invertebrates associated with the ecosystem. Producers should be interested in the benefits of increased yield and yield stability. Also, advantageous is that plant species that are not useable to some livestock species (such as brush for cattle) and dominate the ecosystem are mostly replaced with plants that are useable by cattle.

Vegetation control may be very useful for reducing/preventing wildfires. Goats are effective at reducing the fine-fuel load by as much as 50 percent (Tsiouvaras et al., 1989). This would result in a reduction of the height of the flame front and reduced speed of movement of the flame front, which would make the fire more easily controlled. Based on this research, goat herders are being paid to graze their goats in various areas, especially populated areas, to reduce the fire hazard. Goats have been shown to be as effective as herbicides for maintaining firebreaks.

Since goats are generally used for controlling woody and weedy species, a determination needs to be made of the target species which in turn determines the best grazing strategy to control these plants. An example would be red cedar where, in most regions, goats more aggressively browse this specie during the winter time. For controlling cheat, a weedy grass, the best time of control is late winter before the plant enters its reproductive stage because at that time, it becomes unpalatable to virtually all grazers. Generally in a given area, there will usually be only one to three target species that dominate the available vegetation in an area. Usually, the grazing objective is to control these dominant species so that natural biodiversity is restored to the grassland. Goats will also control other species in addition to the target species. In a few cases, some species are so palatable that they will be virtually eradicated such as poison ivy, johnsongrass or kudzu.

There are several browse species common to most states in the Southeast that are usually undesired and are listed in Table 9.1. There are pictures of these species in Appendix 1 to help identify the plants. Generally, by comparing the leaf shape, these species can be readily identified. Other characteristics such as appearance of the bark or canopy type may be useful in identification. There are several web locations listed in the reference section that are helpful in identifying undesired species. The soil survey for your area often lists invading vegetation species. Your local Natural Resources Conservation Service office or County Extension Educator can also assist you in identifying undesired species. Other resources may be available such as a local vocational agriculture teacher, high school biology teacher, or field service representative from the local farm supply store who may also be helpful in identifying the plant species that you are targeting to control. While identifying target species, you should also become aware of the local poisonous plants in the pasture.

Poisonous plants are generally not much of a problem for goats because goats generally will avoid poisonous plants unless forced to consume them because of an insufficient supply of other forages. This is assuming that the goats were raised in this area. This is because does teach their kids what plants are safe to eat and what plants to avoid. Goats that are brought in from another area and have not been exposed to a given poisonous plant may naively consume the plant, resulting in poisoning. However, another factor that limits toxicity in goats is that given the opportunity, goats will consume a number of different species in a day, reducing the chance of consuming a toxic level of any one plant. Goats also have larger livers as a proportion of body weight, saliva that binds tannins, and microbes that neutralize tannins. They may also have microbes that reduce toxicity in other plants, especially if the goats originated in an area with this plant. There is an exception to this in the Azalea plant family; Mountain Laurel and Rhododendron are quite toxic to goats, and some goats seem to have a great preference for these plants, which initially results in projectile vomiting and ultimately death of the goat. While goats learn to avoid toxic plants, these plants seem to be addictive for some goats because they will not

learn to avoid it. Because there are toxic plants identified in a field, it does not mean that animals should not be grazed. Virtually every plant is toxic at some stage of its lifecycle and therefore if we had to be absolutely safe we would not graze plants, but generally, like in any business, we cannot make money without assuming some risk. However, check with other goat producers and the veterinarian in your area to identify the plants that are commonly responsible for toxicity to goats in your locale. Plants can often be removed with a hoe or may be sprayed by 2,4-D or glyphosate (Roundup) to kill them before goats are pastured in the area. Toxicity may be seasonal in nature and the timing of grazing can prevent intoxication.

Browse species			Nutrient content					
Common name	Scientific name	TDN	СР	NDF	ADF	Calcium	Phosphorus	
			0/0					
Blackberry	Rubus oklahomus		9.7	54.2	39.7			
Smooth sumac	Rhus glabra	77	13.7	31.2	26.5			
Winged sumac	Rhus capallinum	73	14.4					
Poison ivy	Toxicodendron radicans		13.0					
Oak spp.	Quercus spp.		11.9					
Hawthorne	Crataegus viridis							
Green Briar	Smilax bona-nox		17.0	39.5		0.60	0.18	
Elm	Ulmus americana		14.2	49.6	32.5			
Winged elm	Ulmus alata		12.0					
Honey locust	Gleditisia triacanthos		22.4					
black locust	Robinia pseudoacacia		23.8					
Multiflora rose	Rosa multiflora		18.8	34.5		0.99	0.32	
Dogwood	Cornus drummondii		7.4	39.6	29.8			
Kudzu	Pueraria lobata	55	23.4	38.4	36.0			
Honeysuckle	Lomicera japonica	68	10.0	34.5		1.21	0.30	
Privet	Ligustrum spp.		18.0	26.8		0.89	0.34	
Mulberry	Morus spp.	72	17.0					
Sweet gum	Liquidambar styraciflua		7.0					
Poplar	Populus spp.							
Eastern red cedar	Juniperus virginiana	64	6					

Table 9.1. Browse species commonly found in the southeast USA and their nutrient contents.

Forage, Forb, Browse, and Shrub Species Preferred by Goats

Many factors affect the goat's choice of vegetation. A few have been determined scientifically, a few by observation, but most factors are known only to the goat. The major factor affecting the goat's preference for various plant species is what its mothers ate. In the classic studies of Biquand and Biquand-Guyot (1992), it was observed that maternal influence greatly affected diet selection, followed by season of birth. The influence of maternal effects on food preferences in lambs was also demonstrated by Provenza's group (Nolte et al., 1990). The learning of diet preferences from their mother is thought to be a powerful mechanism to avoid toxic plants

although animals are capable of learning to avoid novel toxic plants (Provenza et al., 1988). Therefore, social influence is also a factor in diet selection, dominated by maternal selection. However, diet selection of animals is also learned from their peers. Genetics may also play a role in diet selection being similar to their mother. Waldron et al. (2009) observed a heritability of 0.13 for juniper consumption in goats, indicating potential to select for juniper consumption, but progress would be slow.

Another factor which has been observed, but remains undocumented is that preferences for vegetation may differ with location. It has been observed with red cedar in some locations, that the plant was only consumed during the winter months whereas at other locations, the plant was highly consumed during the summer. Sumac has been observed to be highly preferred at some locations and strictly avoided by cohorts at other locations. Similar observations have been made on poison ivy. Apparently, soil and climate have an effect on the preference for plants. With the state of our understanding, location effects can only be observed retrospectively and not predicted.

Maturity of plant is another factor affecting diet selection. Goats generally do not consume sericea lespedeza seedlings but rather wait until they are about 25 cm high to consume them. Goats will bypass many familiar plant species in a field for days and then one day they start consuming the species. That species may become the dominant species in their diet for several days until it is grazed out. In contrast, some species seem to remain palatable throughout the grazing season. Mast (fruits and seeds of woody vines, trees, cacti, and other non-herbaceous species) is typically only available in the middle or end of the grazing season.

The degree of defoliation of a plant is affected by grazing pressure (number of animals relative to amount of available forage). Wethers can stand a high grazing pressure and provide a high degree of defoliation and control in a short period of time. However, does in late pregnancy or lactation and young kids cannot perform well at high grazing pressure. High grazing pressure with these classes of animals will increase periparturient problems, reduce weaning weight of the kids, and reduce reproduction in the doe. With lower grazing pressure and the consequent lower degree of defoliation, control of the target species will take additional time. Generally, unless one has wether goats and is getting paid for defoliating plants, the goat enterprise is funded by the sale of kids. Therefore, using high stocking densities will reduce enterprise profitability which will make the goat enterprise economically unsustainable.

The easiest way to monitor vegetation utilization is by visual inspection. Do you notice less leaves on the plant where goats can reach them? Do you see places where twigs or leaves were bitten off? This requires closer observation and a good mental picture of the growth habit of the plant. In some cases with highly preferred species, almost all of the above ground biomass will have been consumed and unless you are careful, you will not notice the stubs of these plants close to the ground. Also, when one species that the goats highly prefer such as blackberries are defoliated, another woody species that is present such as buckbrush may become the dominant species and cover over the first defoliated species so that the defoliation is not recognized.
Benefits of Various Browse Species

Browsing is beneficial to the goat's health. Goats are not grazing close to the ground and therefore do not pick up many infective worm larvae resulting in fewer problems with parasitic worms. In studies where we have used goats for vegetation management, we have not had to deworm goats. Sericea lespedeza has been shown to have antiparasitic qualities (Min et al., 2005) which have been attributed to the tannins. However, all tannins are not antiparasitic, such as the tannins from oak species. There may be other browse species with antiparasitic qualities. Browse has typically been described as high quality nutrition. The selectivity of the goat enables it to select a high quality diet of browse provided there is adequate quantity of browse from which to select.

Nutrient contents for browse species are shown in Table 9.1. If there is sufficient browse to select from, goats will select higher quality plant parts for consumption. Sidahmed et al., (1981) showed that goats were able to select a diet that was higher in digestibility than the digestibility of any one component that was available. The feed value for over 200 browse species has been reviewed by Ramirez, (1996), who found them to be only moderate in digestible energy content. Crude protein level averaged 17 percent, but tannins in many browse species may interfere with protein digestion depending on the level in the diet (Woodward and Reed, 1997). Goats have salivary proteins that bind to tannins and have tannin degrading in the rumen which likely reduces the negative effect of tannins. Calcium level is more than adequate in the browse, but average phosphorus level (from Ramirez et al., 1996) is 0.17 percent which is deficient for the goats' requirement and would require supplementation. Some species have levels greater than .25 percent (Table 9.1) which would be adequate for several classes of goats. It was also noted that little is known about trace mineral content of browse.

Sustainable Browsing Management

Although we often think of goats as being used to control woody species, we need to think that goats can be used to manage brush sustainably. This involves a change in mindset, but the South Africans lead in this mindset with the system of management for the brush veldt that is used for livestock production. Brush produces greater and more sustainable yields than grass in these very dry areas, and pastures are grazed so as to maintain the brushy species in these areas. Australian producers also utilize woody species as a renewable resource for their cattle especially Leucaena. The species is a legume, fixing its own nitrogen, a fodder bank during the drought, and has high quality forage which cattle readily graze. The South Africans developed some rules for use of brush as a renewable resource. It must not be grazed early in the spring, it must be rested at least eight weeks between defoliation, no more than 50 percent of the leaf area can be removed at defoliation, and it must not be grazed late into the fall. To control brush, you would implement the opposite grazing management, starting to graze as early in the spring as practical, continuously grazing to repeatedly defoliate the plant as completely as possible, and keeping the plant defoliated into the fall.

While Australia has highly developed Leucaena (*Leucaena leucocephala*) pasture management and the South Africans have developed brush veldt management, there is a need for developing other grazing systems using woody species as a renewable resource. Bransby et al. (1996) and Animut et al. (2007) studied mimosa (*Albizia julibrissin*) for use as a renewable grazing resource. The forage is high yielding (4 tons DM/acre) highly nutritious (61% DDM; 16% CP) and highly palatable, which necessitates good grazing management so that it is not grazed out. The major drawback is that it is difficult to establish.

Black locust (*Robinia pseudoacacia*) has been proposed as a brushy crop, but goats strip the bark readily and kill it (Luginbuhl and Mueller, 2000). Leucaena has been grown in several areas in the South, but does not survive freezing. Bristly locust (*Robinia hispida*) is native to the Southeastern US and has potential for management as a browse species because of survival and shoot proliferation while competing in herbaceous vegetation (David Burner, personal communication).

Tagasaste or tree lucerne (*Chamaecytisus plamensis*) has been utilized in Australia as a browse species, but may not survive below 15°F, which will limit its utilization to the lower South. Another possibility is tree lespedeza (*Lespedeza bicolor*), a legume with brush-like characteristics. It is utilized as an ornamental and for deer food plots. Seed and bare root seedlings are available in volume for transplanting. Forage is high quality and it survives cold weather and drought well. It has great potential for future research. Limited work has been done on *Amorpha fructicosa* as a hedge in alley cropping systems. It is relatively drought resistant, remains a shrub (doesn't grow into a tree out of reach by animals), resprouts vigorously, and is not invasive (Carl Jordan, personal communication).

Other possibilities that have been proposed include Russian olive (*Elaegunus angustifolia*), a shrub that sends sprouts readily from the roots and is readily established from the seed. The roots fix nitrogen, and the shrub is very draught tolerant. It is so well-adapted that it is invasive in the riparian areas of several Western States. Seeds and bare root seedlings are available commercially. It has good potential for a renewable browse species. Fourwing saltbush (*Atriplex canescens*) has been investigated for use with Angora goats and found to be nutritious and high yielding (Ueckert et al., 1988). However, one problem is the lack of cold tolerance, which would limit its range to the lower South.

There are a number of promising plants to use as a renewable browsing resource for goats. There is a serious need for more research before they can become useful. For some, we need to identify more cold-tolerant germ plasm, or accept that they have a limited range of utilization. For some, there is a lack of commercial seed sources and or plants. Most have establishment problems, especially under conditions of limited moisture. Most fix nitrogen and a few have some characteristics of being invasive when not grazed. Forage quality is high and yield is moderate to high. One characteristic of most is that they are quite drought tolerant, which may make them more important if global temperatures increase. Few studies have been conducted to determine where these species best fit in grazing systems. Because of the cost of establishment and moderate yield of high quality, especially high protein content, it has been proposed that they be used as a protein bank to supply supplemental protein when forages are limited in protein. They would be limit grazed during times of need. Since most are highly palatable, some kind of rotational grazing system is needed to support plant persistence.

Goats have been used in silviculture to control competition by hardwood species when establishing new nurseries. Generally ground is prepared for plantation establishment by ripping with a Caterpillar tractor and bare root tree seedlings transplanted and herbicide applied to the soil to prevent competition by other woody and weedy species. In one study where goats were used for pine plantations, goats did control hardwoods and weeds, but toward the end of the season when available forage became limited, they consumed the tops of the pine seedlings. Australians have used goats in tree nurseries. They protected the woody plants from goats by using a strand of electric fence on either side of the plants.

The first 5-10 years of tree growth is slow in a planted pine forest and leaves a significant quantity of resources (light, soil moisture, and fertility) available for pasture growth. As the stand matures and consumes a greater portion of these resources, pasture production declines. If the pasture is predominantly forage, it would be best utilized by cattle or sheep. However, invasive hardwood species are usually a significant problem, competing with pine trees for resources, and goats can consume these hardwood species to remove them from resource competition, and the resources can then be used increasing growth of timber and or pasture, depending on maturity of the trees. Co-species grazing of grazers (such as cattle or sheep) with goats will improve forestry growth as well as providing cash flow to the forest owner while waiting for the forest to grow to maturity and be harvested.

Goats are useful for restoration of riparian areas and streambank vegetation enhancement. Goats do not promote erosion like other species, especially cattle. Cattle follow one another on trails which on sloping ground results in erosion. However, every goat chooses its own path, which eliminates erosion due to trails. We have observed that the sides of stream banks developed vegetation while being grazed with goats, which we attributed to the hoof prints left by goats going down stream banks catching grass seed which became established. Also, cattle will get into the water and foul it and stir up mud. Goats generally do not like to even get their toes wet and will not foul the water or stir up mud. Goats will help to heal these areas with vegetation as long as grazing is managed properly.

References

- Animut, G.; A. L. Goetsch, G. E. Aiken, R. Puchala, G. Detweiler, C. R. Krehbiel, R. C. Merkel, T. Sahlu, and L. J. Dawson. 2007. Effects of pasture inclusion of mimosa on growth by sheep and goats co-grazing grass/forb pastures. Journal of Applied Animal Research. 31: 1-10.
- Biquand, S. and V. Biquand-Guyot. 1992. The influence of peers, lineage and environment on food selection in the Criollo goat (Capra hircus). Appl. Anim. Behav. Sci. 34:231-245.
- Bransby, D. I.; S. E. Sladden, and D. D. Kee. 1996. Forage yield response of mimosa (Albizia julibrissin) to harvest frequency. In: West, N. E., ed. Rangelands in a sustainable biosphere: Proceedings, 5th International Rangeland Congress; 1995 July 23-28; Salt Lake City, UT. Denver, CO: Society for Range Management. pp 64-65.
- Min, B. R., S.P. Hart, D. Miller, G. M. Tomita, E. Loetz and T. Sahlu. 2005. The effect of grazing forage containing condensed tannins on gastro-intestinal parasite infection and milk composition in Angora does. Veterinary Parasitol. 130:105-113.

- Nolte, D. L., F. D. Provenza and D. F. Balph. 1990. The establishment and persistence of food preferences in lambs exposed to selected foods. J. Anim. Sci. 68:998-1002.
- Luginbuhl, J-M, and J.P. Mueller. 2000. Evaluation of fodder trees for meat goats. In: L. Gruner and Y. Chabert (Ed). Nutrition and Feeding Strategies. p. 77-79. 7th International Conference on Goats. 15-18 May. Tours, France.
- Provenza, F. D., D. F. Balph, J. D. Olsen, D. D. Dwyher, M. H. Ralphs and J. A. Pfister. 1988. Toward understanding of the behavioral responses of livestock to poisonous plants. In The ecology and economic impact of poisonous plants on livestock production. L.F. James, M. H. Ralphs and D. B. Nielson (eds). Westview Press, Boulder, CO.
- Ramirez, R. G. 1996. Feed value of browse. in Proceedings VI International Conference on Goats. International Academic Publishers, Beijing, China. p. 510-527.
- Sidahmed, A. E., J. G. Morris and S. R. Radosevich. 1981. Summer diet of Spanish goats grazing Chaparral. J. Range Manag. 34:33-35.
- Tilman, D. 1999. The ecological consequences of changes in biodiversity: A search for general principles. Ecology 80:1455-1474.
- Tsiouvaras, C. N., N. A. Havlik and J. W. Bartolome. 1989. Effects of goats on understory vegetation and fire hazard reduction in a coastal forest in California. American Forester 35:1125-1131.
- Ueckert, D. N., J. E. Huston, J. L. Peterson and J. D. Whipple. 1988. Grazing fourwing saltbush with Angora goats. Sheep and Goat, Wool and Mohair research reports. CPR 4578 pp 30-36.
- Waldron, D. F., C. A. Taylor, Jr., J. W. Walker, E. S. Campbell, C. J. Lupton, T. D. Willingham, and S. Y Landau. 2009. Heritability of juniper consumption in goats. J. Anim. Sci. 87:491-495.
- Woodward, A. and J. D. Reed. 1997. Nitrogen metabolism of sheep and goats consuming Acacia brevispica and Sesbania sesban. J. Anim. Sci 75:1130-1139.

Web Sites for Plant Identification

http://plants.usda.gov/gallery.html. http://www.grownative.org/plants/main.asp. http://www.preen.com/weeds. http://weedid.missouri.edu/. http://www.ag.auburn.edu/agrn/weedsci/weedid/plant/list.php. http://www.ppws.vt.edu/weedindex.htm. http://www.noble.org/apps/plantimagegallery/.

CHAPTER 10 SUPPLEMENTAL FEEDING OF GRAZING GOATS

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Introduction

Ideally, ruminant production should be forage-based because forages can provide most of the nutritional requirements necessary for maintenance, growth, and lactation if the quality and quantities are adequate. In addition, ruminants are less likely to experience various digestive disorders such as acidosis if they are consuming high forage diets. The higher feed and commodity prices in the recent times have further justified the use of higher forage-based diets for ruminants. The current commodity prices are projected to go even higher in 2013. However, in many instances, forages are unable to provide necessary nutrients for grazing animals. These situations warrant needs for additional supplemental feedstuffs to remedy deficiencies in the grazing animal's diet. According to Lusby and Wagner (1987), the main objectives of feeding supplemental feedstuffs to grazing animals are to:

- 1. Improve forage utilization
- 2. Provide supplemental nutrients
- 3. Improve animal performance
- 4. Provide additional carrying capacity (substitution for forages) or
- 5. Stretch forage supplies

Besides, supplemental feedstuffs are also offered to grazing animals to provide a carrier for feed additives, e.g., growth promotants to aid in preventing or treating certain ailments, for handling animals for gathering or checking and to teach calves to eat supplements on pasture before weaning and preconditioning (Vallentine, 2001).

Goats are fed supplements during late summer and during winter months when hay is being fed. If adequate quality forages are available, the only requirements for supplements would be for salt and minerals (Rankins, 2004). The forage program consisting of both browse and pasture has been recommended for goats. An ideal mix is about two acres of browse for every one acre of open grassland, but the problem is to maintain this combination because browse will not grow back once the goats have been on it for more than two growing seasons (Rankins, 2006). The browse species are also very diverse and goats select some browse species preferentially over others. Therefore, the management of browse species as renewable feed resources for goats is not easy.

Grazing animals spend a lot of time walking while gathering forages although the distance traveled depends on the quantity and quality of forages being grazed. In general the energetic costs of grazing increase the maintenance energy requirements. The supplementation may reduce the quantity of energy involved in this activity, but the relationship between the use of supplemental feedstuffs and the utilization of forages and animal performance is very complex (Vallentine, 2001). Many factors affect the relationship which includes the quality and quantity of feedstuffs being supplemented as well as the quality of the forage being grazed. The goal of supplementation is to maintain or increase the digestibility of forage. Otherwise, the whole idea of supplementation will defeat the purpose. The substitution effect should be minimized and forage intake should be enhanced rather than reduced. Most of the time, supplements are better in quality in terms of digestibility. They must increase the digestibility of forages available affect substitution. If the quality of supplements fed is high, the substitution rate increases due to associate effects between the digestion of supplements and the digestion of the forages consumed. The amounts of supplements fed and frequency of feeding also affect substitution rates. The physiological state of the animal also affects the substitution rate. The high nutrient requiring animals have lower substitution rates.

Unique Traits and Behavior of Goats

Understanding the unique behavior of goats is crucial for successful implementation of supplemental feeding for grazing goats. Goats are not very sharing species while they are eating grains or supplements but when they sleep at night, they sleep closely together. There is a hierarchy among goats in the herd. Pinkerton and Pinkerton (2008) have nicely put the following statement to describe goats' behavior. The statement reads, "Gracious, equitable sharing is simply not a caprine characteristic; greed, aggression and sheer size conspire to "cheat" the more civil and/or smaller goats." This behavior is very important for those who are involved in feeding goats. The management strategies should take into account the natural habits of goats. The goat producers can receive economic benefits if they manage their goats to suit their behavior. The strategy to minimize this behavior and to allow equal access to feeds/supplements is very important. For example, goats tend to like dry feeds in pelleted forms compared to meal of flour forms (Pinkerton, 2008). The main problem with dry fine feeds is that they it cause irritation of the upper respiratory tract. But if the moisture levels of the dry feeds are enhanced, there is less irritation (Morand-Fehr, 2003). However, goats do not like liquids diets especially young goats (Bateman et al., 2004). The pellet size is also important. Ideally, size must be about 15 to 20 mm similar to the size fed to cattle. Goats can graze up to 12 to 13 hours a day while the rest of the time, they ruminate. Goats prefer to browse given the opportunity but they can switch their foraging habits when needed. Before introducing goats to new supplemental feedstuffs, they have to be trained to recognize the supplements. The sooner they start eating newly introduced supplements, the faster they benefit. The producers should mix new supplements with previously used supplements and gradually reduce the amount of new supplements. Another method is to mix some experienced animals in the herd. The inexperienced animals will follow the lead.

What are Supplements?

According to Jurgens and Bregendahl (2007), supplements are blends of vegetable, animal protein feeds, or both and may include urea if for ruminants. They are high in specific nutrients such as protein, energy, phosphorus, salt, or other nutrients. Supplements can be harvested forages such as alfalfa meal or high-quality forages grazed simultaneously with poor quality forages.

There are different types of supplements available. They are energy supplements, protein supplements, and minerals supplements. There are many commercial feed supplements that are available in the market as well.

Protein Supplements

Protein supplements are either of vegetable origin or animal origin. Some of the common supplements of plant origin include soybean meal, cottonseed meal, corn gluten feed, corn gluten meal, brewers' grains, peanut meal, sunflower meal, canola meal, distillers dried grain with solubles, etc. Practically speaking, supplements of animal origin are not fed to goats because of the mad cow problem. Supplements can be used to increase low-quality forage digestibility and intake while extending the grazing season. Since most of the protein supplements are of natural protein sources they do not need to be fed every day. Feeding once every two days is adequate. When forage contains eight to ten percent crude protein, a 14 to 16 percent crude protein supplement can be fed daily. Protein supplements containing non-protein nitrogen such as urea can be used, but it is generally recommended against the use of urea supplements in goats in that they seem more sensitive to toxicity. Soybean meal is the most common and palatable protein source and is readily consumed by both cattle and goats, but the cottonseed meal is generally cheaper in the southeastern US.

Energy Supplements

The Southern farms are more likely to have energy deficiencies especially for lactating and pregnant animals than for mature ones (Ball et al., 2007). Therefore, the most expensive part of the diet is energy. Corn is the most common energy source fed to animals, and other energy sources are compared against corn. Some of the commonly used energy sources are soyhulls, whole cottonseed, hominy, molasses, tallow, etc. There are many crop by-products which provide both energy and protein. They include whole cottonseed, peanut skins, wheat middlings, distillers dried grains with solubles, corn gluten feed, beet pulp, brewers grains, and bakery waste, etc. Grains are rich sources of starch and they ferment rapidly in the rumen and may lower rumen pH, resulting in reduced feed intake and digestibility of forages. The ideal practice is to slowly adapt animals to grains and feed limited amounts when used in a forage-based diet. Certain by-product feeds such as soybean hulls, corn gluten feed, beet pulp, and brewers' grains are satisfactory energy sources. They do not reduce ruminal pH as do other sources such as corn. Highly degradable energy sources should be slowly introduced over a period of 3 to 4 weeks to avoid acidosis.

Commercial Feed Supplements

Many feed companies sell such supplements. The labels indicate crude protein, crude fiber, and fat levels, but the energy content is not listed. You can ask the company or their sales representatives for energy content. Supplements also contain additional minerals, vitamins, and selected feed additives. Some protein supplements use non-protein nitrogen (NPN) also but NPN sources are generally not fed to goats because of the toxicity hazard.

By-Products

Whether we call them by-products or co-products, many non-traditional by-products are finding their way into animal feeds. They are by-products of grain milling, food processing, and processing of rendered products. Some of these by-products are attractive because they are locally available and are relatively cheaper if one can buy at the right time. However, we often find producers asking how much should they pay per ton? Byproduct feeds offer opportunities for producers to reduce supplemental feed costs. Several crop by-products are available for goats with potential for greatly reducing feed costs. Some of the popular by-products are discussed below.

Soybean hulls (Soyhulls)

Soyhulls are very popular by-products fed to goats. They are easily available. The fiber level is high but it is highly digestible. The crude protein (CP) levels are about 12 to 14 percent and have a good mineral balance. The energy level is lower than that of corn but when fed at above one percent of body weight, it will have a higher energy value than corn because the starch in corn starts to interfere with the digestion of the forage component of the diet (Luginbuhl et al., 2000). Up to two percent (on DM basis) of body weight can be fed to goats without any problems. Both the loose and pelleted forms are available.

Whole cottonseed

This is easily available in the Southeast. This is a most desirable by-product because there are three nutrients in abundant amounts. The CP levels are about 24 percent and TDN is 90 percent. It is also a good source of fat (24%). It is available in two forms: fuzzy seed with the lint still attached and delinted seed with the lint being removed. The delinted seed is, therefore, higher in protein and fat. The fuzzy seeds are difficult to handle, but usually cheaper. When forages or browse are low in energy, 0.5-1.0 lb whole cottonseed can be used as energy concentrates for goats (Luginbuhl et al., 2000). Whole cottonseed also contains gossypol, a polyphenolic yellow pigment reported to have deleterious effects on male reproduction in some instances (Randel et al., 1992). Up to 16 percent of the diet can be fed to growing male goats without any effects on production and other performance-related measurements (Solaiman et. al., 2009).

Corn gluten feed

It is a by-product of corn starch and corn syrup production from corn grains. The CP level is about 22 percent. Its TDN level is equal to barley. The CP is relatively degraded faster than SBM in the rumen. It is not as palatable as soyhulls but can be included in the grain mixture up to a level of 50 percent. Corn gluten feed is also available as a wet product but is generally dried and pelleted. Corn gluten feed is low in calcium and high in phosphorus. Corn gluten feed is useful in many different types of rations. The by-product can be fed up to one percent of body weight to goats (Lardy and Anderson, 2009). The quality is quite variable and the color of the by-product is a good indicator of the quality. The darker color indicates lower feeding value. In 2011, there were 2.9 million tons of corn gluten feeds produced by U.S. ethanol producers (RFA, 2012).

Wheat middlings

The wheat middlings contain varying levels of bran, germ, and flour which are produced when wheat is milled for flour production. It is highly palatable and can be fed up to one percent of body weight to goats. This byproduct has moderate levels of protein (18 percent) and energy (80

percent TDN) (Lardy and Anderson, 2009). Up to 1lb/animal/day can be fed to goats without any problems. The higher phosphorus levels limit the use of wheat middlings at higher levels. As with other cereal grains, wheat midds are low in calcium and high in phosphorus. Both loose and pelleted forms are available.

Distillers dried grains with solubles (DDGS)

The distillers dried grains with solubles (DDGS) is a corn-based fuel ethanol by-product. It is becoming increasingly available in large quantities, but DDGS is no longer competitively priced in the United States. According to data from the Renewable Fuels Association (RFA, 2012), 35.7 million tons of DDGS was produced in the U.S. in 2011. The DDGS is a unique feedstuff that provides high levels of protein, energy, digestible fiber, and minerals (Schingoethe et al., 2009). Distillers grains contain approximately 28 to 30 percent crude protein, with a relatively high proportion being bypass (escape) protein (Lardy and Anderson, 2009). The DDGS is being used either wet or dry, and performance is usually similar whether fed as wet or dried products (Koger et al., 2010). The wet product can usually be acquired at an advantageous price, but requires storage management. The nutrient composition of DDGS makes it appear to be a suitable supplement for ruminants consuming high forage diets of low to moderate nutrient quality that require additional crude protein (CP) and energy to perform optimally. Because DDGS contains virtually no starch, the negative effects of starch on fiber digestion are not a concern with DDGS supplementation (Schingoethe et al., 2009). In most cases, ethanol production is corn-based, but other grains (barley, wheat, or milo) can be used. Distillers' grains are very palatable and mix well with other ration ingredients. The product can be used to condition or add moisture to dry rations to improve acceptability. The beef producers account for 41 percent of DDGS consumption while the dairy producers use 39 percent. The swine and poultry sectors use nearly 10 percent each (RFA, 2012). Our research showed that up to 31 percent of DDGS can be included in the diet for growing goats on a dry matter basis without any compromise in DM intake, growth performance and carcass quality (Gurung et al., 2012).

Soybean meal (SBM)

The CP quality is excellent and there are so no problems in feeding this by-product to goats. The by-product is available in two forms. The solvent extracted SBM is higher in CP than mechanically processed (expeller processed) SBM. The expeller processed SBM has a higher bypass value compared to solvent extracted SBM. The bypass proteins are potentially available to meet the protein needs of the host animals after digestion in the small intestine.

Peanut skins (PS)

The PS is a locally available and economically sound by-product of the peanut blanching process. It is relatively cheaper than soyhulls and can be fed directly or blends with other ingredients for animal feed. The feeding value of PS has been evaluated for dairy (Utley et al., 1993) and beef cattle (Hill, 2002), but the presence of tannins has limited its feeding value. Goats are known to adapt to moderately high levels of tannins in their diet. The PS is a viable feedstuff for meat goats and up to 30 percent of PS, on as-is basis, can be included in the diet for growing goats without any compromise in DM intake, growth performance and carcass quality (Stone et al., 2009).

Cottonseed meal (CSM)

The CSM is relatively cheaper in the Southeast. The CP level in CSM is about 41 percent and is low in lysine. Also calcium and carotene levels are low in CSM. The CSM contains a yellow pigment called gossypol which is toxic for certain non-ruminant species and also male ruminants. Up to 15 percent of the diet dry matter can include CSM to be fed to growing goats without any problem. The protein and energy content of CSM is approximately 10 and 5 percent lower, respectively, than soybean meal. The level of supplementation depends on intake of free gossypol and types of cotton varieties; however, the CSM serves as a satisfactory protein supplement for ruminant species.

Screenings, grain

Screenings are available from the grain cleaning processes which may include light or broken grain seeds, weed seeds, hulls, chaff, joints, straw, and elevator dust and floor sweepings. Since, the product contains various ingredients in different proportions, the nutritive values are variable. Similarly, the palatability is also variable. Screenings can contain mycotoxins and can also be a source of weeds. The presence of mycotoxins and molds should be tested in the labs before using this by-product. The manure produced after feeding screenings must be composted for about two to three months to minimize weed seed contamination. The information on the use of this by-product to goats is not available.

Molasses

Beet or cane molasses is very popular for use in goat supplements. The primary purpose is for energy (75% TDN) supplement. The other uses are as a palatability enhancing agent, an agent for reducing dust, a binder for pellets and a carrier for urea, a nonprotein nitrogen (NPN) source, vitamins and minerals (Lardy and Anderson, 2009). It is handled primarily as a liquid but is available as a dry product. The inclusion level of dry molasses for goats is eight percent, since; beet molasses may have a greater laxative effect than cane molasses, so a lower inclusion rate of beet molasses is recommended.

Homemade Grain Mixes

If producers have mixing and storage facilities, grain mixes or supplements can be easily mixed at the farm itself. The costs are relatively cheaper than the purchased supplements. Many feed mills have a pelleted mix of feed byproducts for cattle that are acceptable for goats at a competitive price. One of the most common mixes that can be mixed at the farm itself is corn and soybean meal, but the cost of corn is prohibitive presently for doing your own mix. A homemade mixture of 80 percent corn and 20 percent soybean meal is a good example. To calculate the percent protein of the mix, one needs to know the percent protein for corn and soybean meal, which are 8 and 48 percent, respectively. Multiply the percent protein with the amounts in the mix for each ingredient. A 20 percent soybean meal should be multiplied by 48 percent protein which comes out to be 960. Similarly, for corn, multiply 80 X 8 = 640. Add 960 and 640 which totals 1600. Divide 1600 by the sum of corn and soybean meal percentages which equals to 16 percent. That is the percent protein is known. Similarly mineral mixtures can be prepared if percent protein is known. Similarly mineral mixtures can be prepared in the farm. The most ideal mineral mix for grazing goats is a mixture of mineralized salt and dicalcium phosphate at 50:50 ratios that can be fed free-choice.

Supplemental Forages

One of the most promising methods of providing supplemental nutrients and decreasing hay requirements is complementary forage systems based on warm-season perennial grasses and cool-season annual grasses. In areas where year-round forage production is possible, growing high quality forage on a separate piece of pasture and allowing animals to this pasture for few hours every day is useful to fulfill the nutrient requirement of livestock grazing low-quality pasture. Animals can be limit grazed every other day and pull animals off when they get full and lay down. Animals will learn the routine and come in when they get full. There are many forages or combinations of forages that can be grown for supplementation, and about two hours of grazing time per day on the supplemental forages works quite well. The main advantage of this method of supplementation is that both the dominant and submissive animals have equal access to forage. The main concern is that the growth of the forage is weather dependent. Low to medium quality forage (>10% protein) will meet requirements of dry does and non-breeding bucks. When forage or browse is limited or of low quality (<10% protein), weanlings and yearlings should be fed 1.0 lb./day/animal of the standard feeds or one of the by-products. In general, whole cottonseed is not of much use for growing kids because it cannot be fed at a high enough level to have much impact on growth rates. Goats can be forced to eat very low quality feed including twigs and tree bark, but producers should be aware that this practice will hurt the productivity of superior meat and fiber goats.

When to Feed Supplements?

Producers need to identify the first limiting nutrient(s) in their forages before considering supplemental feeding. For instance, if the forage being grazed is limiting in energy, other nutrients such as protein, minerals, and vitamins will be underutilized and animal performance suffers. To do that efficiently, it is important to understand the requirements of the animal and to meet those needs in the most cost-effective manner. Table 10.1 shows the nutrient requirements of different classes of goats while Table 10.2 lists some of the commonly grown forages as hay and selected nutrient content of these forages.

The nutrient requirements of animals depend upon many factors. They include age, sex, breed of animal, quality of diet on offer (vegetation, supplement), environment (climate, rainfall distribution and amount, temperature), heredity, health and physiological status (maintenance, growth, lactation, gestation), activity and exercise (walking to graze and browse), altitude and topography and degree of body condition, ability to use body reserves and body weight of the animal. If producers have a large herd of goats, it is advisable to test forages for protein, energy and minerals but tests should not include iodine and selenium tests as they are very expensive. They can be supplied in the mineral mix. Plant mineral levels can be tested when forages are actively growing and custom minerals can be made to correct the deficiency. But this advice may not be suitable for small producers. If goats have access to browse and forbs, they are less likely to have mineral deficiencies because these plants contain higher amounts of mineral concentrations compared to grasses.

Class of goat	Average	feed	intake**	Crude protein (%)	TDN (%)
	(lb./day)				
Growing doeling, 45 lb ¹	2.4			8.8	56
Growing male kid, 66 lb^2	2.9			9.0	57
Yearling doe, 90 lb^3	4.6			10.0	56
3 year old doe, 110 lb^4	5.0			11.7	69
Mature buck, 220 lb^5	5.3			9.0	55
Dairy doe, 150 lb ⁶	7.5			11.6	71

Table 10.1. Dry matter and nutrient requirements of different classes of goats*.

*Approximations; based on dry matter in the feeds eaten.

**Calculated on basis of the dry matter in the feeds eaten.

¹Growing at the rate of 0.25 lb./day.

²Growing at the rate of 0.25 lb./day.

³Yearling female, last trimester of pregnancy and growing.

⁴Milking 2 qt/day – enough for twins.

⁵Not gaining weight, moderate activity.

⁶Nubian, milking 1 gallon/day of 4.0 percent butterfat.

Source: Pinkerton and Pinkerton, 2000.

Table 10.2.	Hay	crude	protein	and	total	digestible	nutrient	(TDN)	content	of selected	forage
crops.											

	Approximate Usual Nutrient Level					
Cool-season forage crops	Crude protein (%)	TDN (%)				
Alfalfa (early bloom)	17 to 22	57 to 62				
Arrow leaf clover	14 to 17	56 to 61				
Oats	8 to 10	55 to 60				
Orchard grass	12 to 15	55 to 60				
Red clover	14 to 16	57 to 62				
Rye	8 to 10	50 to 55				
Ryegrass	10 to 16	56 to 62				
Soybean	15 to 18	54 to 58				
Tall fescue	10 to 15	55 to 60				
Wheat	8 to 12					
Warm-season Forage Crops						
Annual lespedeza	14 to 17	52 to 58				
Bahiagrass	9 to 11	50 to 56				
Coastal bermudagrass (4 weeks)	10 to 14	55 to 60				
Common bermudagrass	9 to 11	50 to 56				
Dallisgrass	9 to 12	55 to 60				
Johnsongrass	10 to 14	55 to 60				
Pear millet	8 to 12	50 to 58				
Sericea lespedeza	14 to 17	50 to 55				
Sudangrass	9 to 12	55 to 60				
Courses Doll at al 2007						

Source: Ball et al., 2007.

Points to Ponder While Using Supplements

For using supplements, especially by-products, and determining whether to purchase and feed a particular by-product, several important points need to be considered. Otherwise, supplementation programs can be expensive, time consuming, and often unrewarding if done without considering a number of factors as listed below.

- 1. Moisture content, how moist is it?
- 2. Does it provide an economical source of nutrient we need? Does the nutrient complement forages being fed?
- 3. Palatability, do animals like it?
- 4. Is special equipment required to store or feed the product?
- 5. How long can you store this by-product?
- 6. Is the by-product free of contaminants which could be harmful to your livestock?
- 7. Is the by-product available when needed?
- 8. How variable is the by-product in nutrient composition?
- 9. Are they available in small quantities? This is important to small and limited resource farmers.
- 10. Are by-products location specific? Higher transportation costs prohibit the wide spread use of such by-products.

Which Supplement is a Good Buy?

One of the fundamental questions producers are faced with is how to decide whether a byproduct or supplement is a good buy? Determining how much one should pay for a particular supplement continues to be a challenge. The most accurate comparison for various supplements available to a producer should be based on a laboratory analysis and the use of a computer ration formulation program to calculate an appropriate value for each supplement based on either energy or protein or both energy and protein levels. Petersen (1932) was the first person to provide a method for comparing the value of feedstuffs relative to two reference feeds such as shelled corn as an energy source, and soybean meal as a protein source. However, there are some fundamental flaws with these questions. They do not take into account additional nutrients because of the difficulty in identifying proper reference feeds. Feedstuffs with valuable characteristics other than nutrient content (e.g., products that reduce separation or products that enhance palatability) are not properly evaluated.

However, if the supplement is an energy source, it can be compared to a single corn price relative to TDN. Corn has been given an index value of 100 and the relative value of each energy source is expressed as a percentage of this value. Similarly, cost per unit of crude protein can be compared with soybean meal.

Goats can be fed supplements or grains on the ground by making a layer. This method is commonly practiced by small producers. This helps spread grains evenly and uniformly to facilitate equal access to goats of different sizes. The frequency of feeding, however, affects the uniform availability of supplements. If supplements are not fed daily, shy and submissive goats would not be able to receive their fair share because they are dominated by dominant animals. The problem is wastage of supplements of grains. A sheep report showed that up to 10 percent of the grain or supplements may be wasted if fed on the ground and this should be discounted for when working the feeding rates (Court et al., 2010). The problem with the method is that the ground should be dry and on higher levels. If the grounds are wet, goats can pick up parasites. It is advisable to move the feeding place each feeding time. Goats can be fed on feeding troughs. This method helps minimize wastes but the space must be enough for each goat to have equal access. Even with adequate space, dominant goats try to run away submissive goats, the shy feeders, young goats and goats that are in poor condition. Make sure to design feeding troughs in such a way as to minimize mold growth and fecal contamination while feeding supplements in feed troughs. The trough space requirements depend on the size of the animals and whether they are very indoors or outside open in the pasture.

Hands-on Activities

The following hands-on activities are recommended for producers to successfully implement supplementation strategies in their farms.

- 1. Identification of different types of supplements/by-products available for use in goats.
- 2. Evaluation of supplements/by-products for texture, particle size, color, and smell.
- 3. Calculation of individual supplements with respect to their nutrient contents. For example, producers will be able to calculate cost/unit nutrient content and compare between two supplements or by-products.
- 4. Using Ration Balancer and Nutrient requirement calculator program developed by Langston University to calculate nutrient needs and diet formulation for different classes of goats.

Key Points

- 1. Proper decision making for use of supplemental feeds starts with identifying the need for supplementation and the nutrient composition of available feeds and supplementing for rectifying deficiencies in the diet.
- 2. While feeding animals in groups make sure each animal in the herd gets its share. This can be accomplished by adopting feeding methods that keep the grazing animals well distributed.
- 3. Finally, routine monitoring and evaluation of the supplementary feeding program is necessary to determine its progress and performance to ensure that it is economical to continue.
- 4. For assistance in calculating the supplement required in your feeding program, contact your local county agents or nearby Agriculture University.

References

Ball, D.M., C. G. Hoveland, and G. D. Lacefield. 2007. Southern Forages, 4th ed. International Plant Nutrition Institute (IPNI), Norcross, GA. p. 26-39.

Bateman, H. G., T. W. White, C. C. Williams, and S. Alford. 2004. Goat preference for concentrates of forages is influenced by physical and chemical characteristics of the feed. Prof. Anim. Scientist. 20:198-204.

- Court, J., J. Webb Ware, and S. Hides (Eds.). 2010. Alternative Feeds. Pages 128-129 in Sheep Farming for Meat and Wool. CSIRO Publishing, Victoria, Australia.
- Dove, H. 2010. Ingestive behavior, diet selection and feed intake. In: Sandra Solaiman, editor, Goat Science and Production, Wiley-Blackwell, A John Wiley & Sons, Inc., Publication. 2010 Blackwell Publishing. Ames, IA. p. 179-192.
- Gurung, N. K., S. G. Solaiman, D. L. Rankins, Jr., A. L. Kendricks, G. M. Abdelrahim, and W. H. McElhenney. 2012. Effects of distillers dried grains with solubles on apparent nutrient digestibility and passage kinetics of Boer x Spanish castrated male goats. J. Appl. Anim. Res.*doi*:10.1080/09712119.2011.640205.
- Hill, G. M. 2002. Peanut by-products fed to cattle. Vet. Clin. North Am. Food Anim. Pract. 18(2):295-315.
- Jurgens, M. H. and K. Bregendahl. 2007. Animal Feeding and Nutrition. 10th ed. Kendall/Hunt Publishing Company, Dubuque, IA.
- Koger, T. J., D. M., Wulf, A. D. Weaver, C. L. Wright, K. E. Tjardes, K. S. Mateo, T. E. Engle, R. J. Maddock, and A. J. Smart. 2010. Influence of feeding various quantities of wet and dry distillers grains to finishing steers on carcass characteristics, meat quality, retail-case life of ground beef, and fatty acid profile of longissimus muscle. J. Anim. Sci. 88:3399-3408.
- Lardy, G. and V. Anderson. 2009. Alternative Feeds for Ruminants. NDSU (North Dakota State University), AS-1182 (Revised). Accessed Feb. 12, 1013. <u>http://www.ag.ndsu.edu/pubs/ansci/livestoc/as1175w.htm.</u>
- Luginbuhl, J. M., M. H. Poore, and A. P. Conrad. 2000. Effect of whole cottonseed on intake, digestibility and performance of growing male goats fed hay-based diets. J. Anim. Sci. 78:1677-1683.
- Lusby, K. S. and D. G. Wagner. 1987. Effect of supplements on feed intake. In: F. N. Owens, editor, Feed intake by beef cattle. Oklahoma State University. Publ. 121. p. 173.
- Morand-Fehr, P. 2003. Dietary choices of goats at the trough. Small Rumin.Res. 49:231-239.
- Petersen, W. M. E. 1932. A formula for evaluating feeds on the basis of digestible nutrients. J. Dairy Sci. 15:293-297.
- Pinkerton, F. 2008. A Compilation of the Wit and Wisdom of "The Goat Man". Hankins Enterprises, Sarah, MS.
- Pinkerton, F. and B. Pinkerton. 2000. Supplemental winter feeding of goats. Accessed Feb. 15, 2013. www.clemson.edu/agronomy/goats/winter_feed.html.
- Randel, R. D., C. C. Chase, Jr., and S. J. Wyse. 1992. Effects of gossypol and cottonseed products on reproduction of mammals. J. Anim. Sci. 70:1628-1638.
- Rankins, Jr., D. L. R. 2004. By-product feeds for Alabama beef cattle. Alabama Cooperative extension System. ANR-1237.
- Rankins, Jr., D. L. R. 2006. Feeding a Goat Herd. Proc. Alabama Cooperative Extension Program Publication, Auburn University, Auburn, Alabama.
- Renewable Fuels Association. 2012. http://www.ethanolrfa.org/.
- Schingoethe, D. J., K. F. Kalscheur, A. R. Hippen, and A. D. Garcia. 2009. Invited review. The use of distillers' products in dairy cattle diets. J. Dairy Sci. 95:5802-5813.
- Solaiman, S. G., N. K. Gurung, Q. McCrary, H. Goyal, and W.H. McElhenney. 2009. Feeding performance and blood parameters of male goat kids fed EasiFlo® cottonseed. Small Rumin. Res. 81:137–145.

- Stone, A., N. Gurung, S. Solaiman, D. Rankins, Jr., G. Abdrahim, and W. McElhenney. 2009. Effects of feeding peanut skins on growth performance and carcass traits of Kiko × Spanish growing male goat kids. J. Anim. Sci. Vol. 87, E-Suppl. 2/J. Dairy Sci. Vol. 92, E-Suppl. 1., 484.
- Utley, P. R., G M. Hill and J. W. West. 1993. Substitution of peanut skins for soybean hulls in steer finishing diets containing recommended and elevated crude protein levels. J. Anim. Sci. 7:33-37.
- Vallentine, J. 2001. Grazing Management. 2nd ed. Academy Press, San Diego, CA.

CHAPTER 11 PASTURE-WEED IDENTIFICATION, BIOLOGY, AND MANAGEMENT

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Introduction

Weed management is a critical component of almost all forage production systems. Weeds are most easily defined as "plants out of place." They may also be defined as those plant species that may cause economic losses in production systems, environmental harm in natural systems, or even cause direct harm to human or animal health (Bryson and DeFelice, 2009). In pastures, weeds may negatively impact forage production by competing with desirable forage species for limited resources and also impact forage quality as contaminants in hay (Fischer et al., 1982). Some weeds may also be injurious or poisonous to livestock and can cause sickness or even death (Frandsen and Boe, 1991). For forage producers, it is critical to have a basic understanding of pasture weeds to be able to make the best informed decisions for pasture management and keep animals healthy.

In forage systems, what is defined as a weed often depends upon the class of livestock being raised as different classes of livestock exhibit different species preferences. The difference in animal grazing preference often dictates the weed management strategies used. For example, for cattle, many broadleaf herbaceous and woody plants are considered weeds as cattle exhibit a preference for grasses (Popay and Field, 1996). This tends to drive cattlemen to employ management strategies to control most broadleaf and woody plants to maximize grass production. For sheep, many of the same broadleaf plants are preferred forage species, and for goats, many of the same woody species are highly desirable. Grazing preferences are not always absolute; animal stocking rate and forage availability can dictate what animals will consume.

Specifically for goats, exactly what is defined as a weed is often somewhat blurry. There is an old adage that goats will eat just about anything and in many cases, it appears to be true. However, it is not always true as there are many weeds that goats are rarely interested in such as Carolina horsenettle, coffeeweed, dogfennel, broom snakeweed, and camphorweed. The adage stems from many observations that goats can be extremely effective vegetation managers in many situations and may even be too effective when not properly managed. The old idea of goats eating tin cans actually comes from their interest in eating the labels off the cans. This does, however, provide goat producers with a different view of many pasture species we commonly refer to as weeds as they can successfully be part of the forage base.

Some Basic Weed Biology

While the sheer number of weeds may seem overwhelming, one can begin to overcome that by understanding a little basic biology. There are three life cycles that weeds exhibit: annual, biennial, and perennial.

Annuals

Annuals survive less than one year. They germinate from seed lying at or just below the soil surface, grow vegetatively, flower, produce seed, and then die. They are dependent on seed production to ensure survival of the species. The seed often stay in the soil for several years, so stopping all seed production for a single year will not eliminate the species. Annuals can further be divided into species that grow in warm conditions (summer annuals) and species that grow in cool conditions (winter annuals). Summer annuals germinate in the spring and summer. They grow and make seed over the summer and then die in the fall. Some common summer annuals include pigweeds, bitterweed, horseweed, and crabgrass. Winter annuals germinate in the fall through late winter. They produce seed in the spring and die as summer approaches. Some common winter annual weeds include henbit, some buttercups, and chickweed.

Biennials

Biennials survive for less than two years. In the first year, they germinate and form a low growing leafy rosette. They survive winter and in the second year, elongate flower stalks (bolting), flower, produce seed, and die. In a few cases, some individuals may persist as rosettes for more than a year before flowering, but they still only produce seed once. Biennials also depend completely on seed production for survival and often form long-lived seed banks in the soil. In a given year, the biennial population you see in a pasture will be a mix of first year plants and second year plants, which is why they don't all flower each year. Musk thistle and common mullein are good examples of biennial species.

Perennials

Perennials survive more than two years. After germination, they begin to grow and can reproduce sexually and asexually. Perennials reproduce by seed and also form soil seedbanks. Additionally, perennials often have many dormant buds on root crowns, lateral roots or rhizomes that produce new shoots. Perennials may be simple (dandelion and dogfennel), creeping (Carolina horsenettle), or woody (trees, shrubs, and some vines). Perennial weeds are generally much more difficult to control due to both seedbanks and a large root network that is tough to completely kill. Perennials often store considerable energy in the form of total non-structural carbohydrates (TNC) in the roots that is used to initiate new shoot growth before leaves begin photosynthesizing. Available energy reserves in the roots also follow a seasonal pattern that is relevant for weed control operations. For herbaceous weeds, TNC peaks in the fall, is slowly depleted to a low level by early flowering in the spring or early summer, and then recovers to a high level in the late summer or fall. Applying control measures when TNC levels are low (just at flowering) or during active TNC translocation to the roots (late summer or fall) are often the most effective times for herbaceous perennial weed control.

Weed Dispersal Mechanisms

Weeds are very effective in getting around by several mechanisms. Many weeds have attractive fruits that birds feed on. The seeds then pass through the digestive tract and readily germinate when deposited in the feces. Privet is a good example of this (Panetta, 2000). Other seeds have Velcro like hooks that attach to hair, fur, and clothing. Cocklebur and Devils beggarticks are well known for this. Still other seeds are very light and are easily dispersed by wind such as dandelion

or float and are dispersed by water (popcorntree). While we cannot easily stop natural seed dispersal, it is very clear that humans spread many weed seed via mowing after seed production. This is most obvious when pastures are mowed in the late spring when thistle seed is starting to blow.

For goat producers, when weeds begin to set seed, people often wonder if goats are spreading seed through their feces. While the answer varies by weed species, many seeds ingested by goats are destroyed and are not viable when passed with the feces. However, goats may still spread many seeds that are caught in the hair and in soil on the hooves. For common pasture weeds that are already widespread, this is not a major problem. However, for noxious and invasive weeds, this is very important to recognize, and you should make every effort to prevent the spread of invasive weeds.

Pasture-Weed Management

One of the most important concepts to remember for pasture-weed management is that there are no silver bullets for weed control. By this, we mean that no single strategy applied one time will effectively solve all weed problems. Even though most forage systems are perennial based, we must still employ management on an annual basis, just as is done in many agronomic cropping systems. The reason we have no silver bullets relates back to the basic biology of the weed species. Weeds often form long-lived soil seedbanks, are effectively dispersed in many ways (wind, water, equipment, birds, and animals), and are very opportunistic in response to many forms of disturbance. These characteristics ensure survival. Therefore to best address weed problems, integrated pest management (IPM) is an approach that utilizes as many of the tools that are available as possible in a planned, coordinated fashion. IPM methods often involve cultural, physical, biological, and chemical approaches (DiTomaso, 2000).

Cultural Control

For permanent pastures, cultural weed control methods include common sense techniques that should be done as part of any good pasture management program. These include maintaining pasture fertility and soil pH to favor desirable forage species, avoiding planting weedy species, and avoiding accidentally spreading weed seeds to uninfested pastures. Two ways this often occurs is through mowing after weeds have set seed or not holding animals for a few days before moving them from infested to uninfested pastures.

Physical Control

These methods involve any technique that uproots, buries, cuts, smothers, or burns weeds. Hand pulling and cutting are two commonly used physical methods in pastures. Burning is frequently used in pine plantations, but is not as common in pastures. Hand pulling is useful for removing small stands of weeds but is extremely labor intensive when weeds cover the entire pasture. A good method of thistle control that is often overlooked is cutting the taproot about three inches below the soil surface with a shovel. Annual or biennial thistles only sprout from the root crown just at the soil surface, making this method very effective.

Biological Control (Biocontrol)

Biological control involves the use of living organisms to lower the population of a weed to a level below which it is no longer a problem. Geese are a classic example of biocontrol for grass weeds in certain crops, while sterile carp have been used to control aquatic weeds in lakes and ponds. Insects and certain pathogens have also been used to control specific weeds. A good example in Alabama is the musk thistle seed weevil, which consumes many of the seed in the flower heads of musk thistle. Unfortunately, we do not have many insects we can use for weed biocontrol in Southeastern pastures. However, grazing animals act as a type of biocontrol, and can be very effective in managing many weeds.

Chemical Control

This method involves the use of herbicides to suppress or control weedy species. While many goat producers do not frequently use herbicides, some situations may arise where an herbicide treatment is needed. For example, a severe infestation of Carolina horsenettle may need to be treated since goats strongly avoid it. It is important to understand that commonly used pasture herbicides can be safely used for weed control without harm to the goats. Most pasture herbicides, if ingested by goats that consume treated forage, will pass through the goats via the feces and urine. They do not accumulate in the fat or meat of goats, nor do they make goats sick. However, you should always follow the herbicide label with regards to grazing restrictions, which may require a delay in grazing of a few days after treatment. Additionally, since pasture herbicides move through the animals, certain herbicides may still be active in the urine and feces that pass out of the animal and nontarget injury may result on susceptible plants. This has occasionally been a problem where animals grazed a recently treated pasture and were then moved to a new area with plants susceptible to the herbicide such as clovers. If you are interested or need to find a specific herbicide label, the following website (www.cdms.net) is free for current herbicide labels. Commonly used pasture herbicides here in Alabama include 2,4-D, dicamba, aminopyralid, picloram, metsulfuron, and triclopyr. There are several trade names for these products and specific pasture weed control recommendations can be found at Alabama Cooperative Extension's website in the 2013 Alabama Pest Management handbook, Volume 1. http://www.aces.edu/pubs/docs/A/ANR-0500-A/.

IPM Strategies

Unfortunately, pasture weed control is often done in a reactive fashion. Each year, weeds are often "out of sight, out of mind" until they begin to take over pastures. At this point, growers scramble to implement weed control measures. This process is repeated over and over each year. A lack of time is often blamed for not planning ahead. However, all livestock producers who have pastures must recognize that they are first and foremost forage growers. Without the forage base, they will not stay in the livestock business. A better, proactive approach entails developing a yearly weed control plan, making note of where troublesome weed patches reoccur each year through simple weed mapping, noting certain species that may be spreading, and observing how weeds respond to different management strategies (DiTomaso, 2000). This approach allows for more successful adaptive management, because you will be able to adjust your weed control based on an ever increasing knowledge of your pastures.

Goat Grazing and Weeds

There is a very marked distinction between the foraging preferences of cattle, sheep, and goats (Thomsen et al., 1993; Walker et al., 1994). While cattle exhibit a preference for grasses and sheep tend to favor forbs, goats typically prefer a diet composed primarily of woody browse and forbs. The great news here is that many of our common troublesome pasture weeds fall into the preferred diet of goats. Now, this does not mean that all goats prefer all woody browse and forb species equally. Goats exhibit selectivity among plant species. Some of the most highly preferred weedy species include blackberry, greenbrier or smilax, sumac and winged sumac, winged elm, poison ivy, ironweed, sericea lespedeza, mimosa, and kudzu (Bauni, 1993). Note that many of these cause great trouble for cattlemen! Some moderately preferred species include post oak, blackjack oak, multiflora rose, sunflower, and thistles (Bauni 1993). Lesser preferred species include Osage orange, hackberry, and common and giant ragweeds (Hart, 2001). Finally, there are some species that goats are very reluctant to eat. These include sicklepod, Carolina horsenettle, and common mullein. While it is not clear exactly why these species are so undesirable to goats, it will be wise to watch for them increasing in your pastures. If they do, you may need to alter your management strategies. Clearly, none of these lists are exhaustive and there are many more species that will fall into each of these categories.

Now, having listed all these species, you also need to understand two more key points about diet: 1) Goats' foraging preferences may change with the season and 2) a goat's foraging preferences may be inherent and/or learned from its mother or peers. These are things that you should watch for in your own herd. Maternal knowledge is often passed down through the herd so if you recognize certain mothers have specific foraging patterns, and then you can often expect their offspring to pick up on those patterns. In this way you can work to build and cull a herd with vegetation management purposes in mind.

Overcoming diet preferences through stocking rate: Managers can also change the foraging behavior of their goats by altering the stocking rate in a given pasture. At low stocking rates (fewer animals per area), goats, sheep, and cattle will forage very selectively and utilize the most preferred species first. This can result in certain highly desired species actually being grazed out of the pasture due to overuse. However, as you increase the stocking rate, grazing animals become less selective and will utilize vegetation more uniformly (Olson, 1999). This may actually preserve many of the more preferred species since everything is essentially "taking a hit." This is called high intensity grazing. High intensity grazing can be efficiently used to manage many species that are moderately or less preferred by goats. Depending on the stocking rate and pasture size, animals may be kept in a certain area for as little as a few hours to a few days, but the duration is generally short. Linking high intensity grazing to short duration is also called flash grazing. Recognize that this approach requires portable fencing and water, time, and your attention to prevent pasture overuse. High intensity short duration or flash grazing is very commonly used by contractors who use grazing for vegetation and invasive plant management.

Hands-on Activities

1. Weed identification and demonstration of weed life cycles: Participants will learn to identify some of the most common pasture weeds in Alabama and some of the most important

invasive plants in the Southeast. These will include examples of winter annuals, summer annuals, herbaceous perennials, and woody species. Live specimens will be collected and presented to the group. Key identifying characteristics will be discussed in addition to relevant biological and ecological points.

2. Demonstration of weed control tools and methods: Participants will be shown multiple tools used for pasture weed control. These will include mowing and cutting tools, weed wrenches, sprayers, herbicides, and biological control agents for musk thistle. A simple sprayer calibration method will be demonstrated, and effective broadcast and individual plant treatment methods will also be shown.

Key Points

- 1. Pasture weeds are everywhere in Alabama and there are no "silver bullets" for weed control. Pasture weed control is important each and every year.
- 2. The basic life cycle of most pasture weeds is important to know. Examples include winter and summer annuals, biennials, and herbaceous and woody perennials.
- 3. Weeds often have multiple, effective dispersal mechanisms including wind, water, birds, animals, and human mediated strategies.
- 4. Pasture weed control is best approached with Integrated Pest Management (IPM) strategies that include cultural, physical, biological and chemical tools. Integrating different methods often improves control over single method approaches.
- 5. Goat dietary preferences and grazing management strategies dictate what a weed is and what is not. Many typical weeds are readily consumed by goats. However, those that are not will require additional management tools.
- 6. Comments: Different stages of weeds toxic to animals according to season and growth stages- needs to be added.

References

- Bauni, S. M. 1993. Utilization of cross timbers rangelands by Angora goats. Ph.D. dissertation. Oklahoma State University, Stillwater, OK.
- Bryson, C. T. and M. S. DeFelice, eds. 2009. Weeds of the South. University of Georgia Press, Athens, GA.
- DiTomaso, J. M. 2000. Invasive weeds in rangelands. Species, impacts and management. Weed Sci. 48:255-265.
- Fischer, M. L., J. F. Stritzke, and R. M. Ahring. 1982. Germination and emergence of little barley (*Hordeum pusillum*). Weed Sci. 30:624-628.
- Frandsen, E. and D. Boe. 1991. Economics of noxious weeds and poisonous plants. In: L. F. James, J. O. Evans, M. H. Ralphs, and R. D. Child, editors, Noxious Range Weeds. Westview Press, San Francisco, CA. p. 442-458.
- Hart, S. P. 2001. Recent perspectives in using goats for vegetation management in the USA. J. Dairy Sci. 84(E. Suppl.):E170-176.

- Olson, B. E. 1999. Grazing and weeds. In: R. L. Sheley and J. K. Petroff, editors, Biology and management of noxious rangeland weeds. Oregon State University Press, Corvallis, OR. p. 85-96.
- Panetta, F. D. 2000. Fates of fruits and seeds of *Ligustrum lucidum* W. T. Ait. and *L. sinense* Lour. maintained under natural rainfall or irrigation. Aust. J. Bot. 48: 701-705.
- Popay, I. and R. Field. 1996. Grazing animals as weed control agents. Weed Technol. 10:217-231.
- Thomsen, C. D., W. A. Williams, M. Vayssieres, F. L. Bell, and M. R. George. 1993. Controlled grazing on annual grassland decreases yellow starthistle. Calif. Agr. 47:36-40.
- Walker, J. S, S. L. Kronberg, S. L. Al-Rowaily, and N. E. West. 1994. Comparison of sheep and goat preferences for leafy spurge. J. Range Manage. 47:429-434.

CHAPTER 12 MANAGING EROSION IN GRAZING SYSTEMS

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Introduction

Almost from the beginning of time erosion has occurred around the earth. From the tallest of mountains to the smallest of streams, erosive forces have caused soil particles to detach and move to another location. This concept is called erosion. Natural erosive forces are found all around us and include water as raindrops, ice, or streams; wind, and earthquakes. Other forces such as man-made traffic or disturbance by confined animals can be disruptive as well. These forces work to break apart soil aggregates into individual soil particles. The soil particles are then moved to other locations suspended in water, attached to or pushed by ice, or shifted by wind. The effect of erosion can be significant. Productivity of the soils is decreased as soils are eroded and the valuable, nutrient-loaded topsoil is carried downstream and deposited in lowlands, streams, ponds or other areas, away from its point of origin.

Dave White, Chief of the NRCS, recently wrote to employees that "In 1937, President Franklin D. Roosevelt wrote a letter to state governors urging immediate action to conserve our Nation's soils. He wrote, 'The Nation that destroys its soil, destroys itself.' That statement rang true in the aftermath of the Dust Bowl and is still true today. Soil is one of the most important natural resources our Nation – and the world – has. Simply put, soil is the factory of our food."

The days of the "Dust Bowl" are evidence of the power of wind erosion. The alluvial fans at the confluence of major rivers such as the coastal zones in Louisiana where the Mississippi River empties into the Gulf of Mexico are evidence of the extent and power of water-based erosion. To reduce erosion and its impacts one must understand where and how erosion occurs. The focus of this manuscript is managing erosion in grazing lands.

Types of Erosion and Causes of Erosion in Grazing Systems

There are four types of water erosion that should be considered.

- Inter-rill erosion the detachment of soil caused by rain splash and the soil particle transport by this surface water flow (sometimes called sheet erosion)
- Rill erosion erosion by concentrated water flow in small rivulets
- Gully erosion erosion by water runoff scouring large channels (deeper than 1 foot)
- Streambank erosion erosion by stream flow cutting into the stream banks

Inter-rill erosion considers the effects of rain splash and subsequent soil particle detachment. Ultimately the soil particles are moved with the assistance of the flowing water. Some particles are pushed around, others become suspended and may be moved a long distance before the water velocity slows enough for soil particles to settle back to the surface. Inter-rill erosion occurs between the rills.

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Rills are small channels that result when surface water begins flowing down gradients in a concentrated form. The water flow in these small rills will eventually lead to larger rills. If the water flow is not managed the rills can eventually lead to gully erosion.

Gully erosion is the culmination of unabated rill erosion. Gully sizes are dependent on the soils, plant cover and length and amount of rainfall events. Some soils are inherently more susceptible to erosion because of the mixtures of sand, silt, and clay, as well as the lack of natural binding of particles by soil-borne microorganism exudates.

Streambank erosion is caused primarily from the flow of runoff water during significant rainfall events such as high intensity rains in short durations or lengthy periods of rains. The extent of the streambank erosion can be magnified when livestock are allowed to access the streams in an uncontrolled manner.

Livestock and Erosion

In grazing systems, weather, soils, landscape, soil cover, soil conditions, and livestock management greatly influence soil erosion. During wet weather conditions and soggy soils, the livestock can cause significant damage to the soil by pugging and breaking up the soil structure. The pugging can also disrupt plant roots causing some plants to die and reducing coverage of the soil surface. During drier conditions livestock can cause damage to the protective plant cover by overgrazing, forming trails, damaging banks along streams, ponds, or springs. Unprotected soil surfaces are susceptible to the impact from raindrops and subsequent detachment of soil particles. Ultimately, poorly managed livestock are the disruptive forces that start breaking down soil structure and aid in damaging the protective grass cover.

Remedies of Erosion in Grazing Systems

So, how does one reduce erosion in grazing systems? It seems obvious that protecting the soil surface from the impact of raindrops, reducing surface water runoff, and properly managing livestock are important in controlling erosion. The following is a brief discussion of erosion controlling remedies in grazing lands.

Protecting the soil surface and reducing surface water runoff in perennial pastures means maintaining good stands of perennial forages in the pastures. Grass coverage should exceed 80 percent for successful reduction in raindrops contacting the soil and to reduce surface water runoff, enhancing water infiltration into the soil. The grass coverage includes both the plant parts in direct contact with the soil surface but also the stems and foliage above the soil surface. So maintaining adequate foliage above the soil surface will reduce erosion. More plant foliage and surface coverage means less erosion.

Surface water runoff is reduced when the water encounters resistance on the soil surface, slowing its movement, and allowing the water to be absorbed by the soil. In general, surface water runoff is inversely related to higher levels of plant cover from foliage and stems.

Plants also help to reduce erosion because of their ability to bind soil particles with their roots. Less erosion occurs when there are more plants and the plants have healthier root systems. Plants have good, healthy root systems when they are properly managed. That is, the plants are allowed proper resting periods between grazing events, and are not over-grazed. Plants that are allowed between 21 days and 35 days of rest, or more, are actually healthier than plants without the rest. The rest allows the plants to replace carbohydrates that are removed during grazing. The carbohydrates manufactured by the plant are important in maintaining both leaf and root growth and thereby maintaining a healthier plant.

As noted above livestock, can be an erosive force when they are not properly managed. Livestock can overgraze grasses, reducing coverage of the soil surface and allowing increased raindrop contact with the soil surface. Under wet conditions livestock hooves can break down the soil structure and damage plants, reducing surface protection from raindrops. The likelihood of soil erosion is significantly increased because the loosened soil particles can now be easily transported with surface water runoff.

When livestock are not properly managed they can cause damage to soils near water sources such as ponds, streams, or watering facilities due to high traffic, wet conditions, overgrazing, and loafing. Managing livestock so that these sensitive areas are protected from degradation is important. Management can include exclusion, controlled access, providing alternative water sources, creating excluded riparian areas, or limiting access to lightweight livestock.

Livestock can cause soil compaction which decreases water infiltration into the soil and increases surface water runoff. Compaction can result when livestock graze areas with wet soils or continuously graze pastures and do not allow resting periods for grasses (see above comments on resting of grazed plants). However, these compaction issues can be minimized or eliminated with assistance of plants and with proper livestock management. The plant foliage is important in providing energy through photosynthesis for root growth. Roots support soil structure which promotes water infiltration. As part of a natural growth process, roots periodically die. The dead roots add organic matter to the soil which, in turn, supports soil microbes and ultimately improves the soil water-holding capacity. Compaction problems caused by livestock can be improved with increased soil organic matter and better soil structure. This is achieved by implementing grazing systems that allow proper rest for grasses, promote improved nutrient recycling and distribution, and promote improvements in soil biota.

Livestock can initiate erosion problems when they are left in a pasture too long. The livestock can overgraze, or spot graze, certain areas that can lead to a reduction in plant cover. They can also create livestock trails to favored areas of the pasture such as watering sites, sheds, feeding areas, or loafing areas.

Solutions and Key Concepts to Grazing Lands Erosion

Good grass management and grazing management are important in controlling the erosion problems. Management strategies could include exclusion of livestock, limiting livestock access to sensitive areas, rotational grazing, strip grazing, limit grazing, and weed control. All of these strategies involve using proper stocking densities, moving animals before overgrazing can occur,

keeping forages healthy with grazing and nutrient management, and managing livestock access to water.

Conservation Planning: The Key Process in Implementing Proper Grazing Management

For those professionals whose motivation is to protect and use wisely our natural resources, conservation planning is the map that guides the process. The management decisions developed in the conservation plan are resource based and require a good understanding of the natural resources involved in the activities.

How are Resource Based Conservation Plans Developed?

In our country, the USDA- Natural Resources Conservation Service (NRCS) is charged with providing assistance to land users in the protection and wise use of all of the natural resources. The conservation planning process that is followed by the NRCS is a good process to develop a conservation plan for a grazing operation. The basic concepts of the process are below:

- Identify resource concerns in conservation planning
- Inventory the natural resources
- Identify client objectives
- Concur on conservation practices to address resource concerns
- Identify alternative actions to address resource concerns or utilize natural resources
- Identify and plan appropriate operation and maintenance strategies
- Develop contingency plans

When developing a conservation plan, both the planner and the land user must agree that certain resource concerns are present. A certain amount of knowledge and salesmanship may be required to achieve this concurrence. Without this agreement the process of developing the plan is severely hindered. The natural resource concerns that might be present in a grazing situation include plant health, animal health, soil quality, soil erosion, water quantity, water quality, and air quality.

An inventory of the natural resources can be completed while the planner and land user come to an agreement on the resource concerns that should be addressed in the conservation plan. Information that is often needed for grazing management plans include:

- Land user objectives,
- Amounts, types and health of forages,
- Livestock type and number,
- Operation type,
- Birthing periods,
- Number and size of pastures,
- Understanding of various grazing management concepts and willingness to implement them,
- Soil types,

- Existing fences,
- Sources of water,
- Water facilities,
- Shade,
- Environmentally sensitive areas,
- Weeds,
- Cultural resources,
- Threatened and endangered species and
- Invasive species.

There are other types of information that may be needed and that will usually be discovered during the planning process. Ultimately, both the planner and land user want to have a very good understanding of the expected dry matter production compared to the expected dry matter needs for the livestock, for now and in the future. Consideration should be given to where deficiencies exist in meeting the animal dry matter needs. Typically, fall and winter have the greatest dry matter deficiencies in grazing operations. However, using warm-season and cool-season forages will support extended grazing periods. Developing alternatives that address the dry matter needs will aid the land user in making planning decisions.

NRCS offers a number of conservation practices that, when implemented, can significantly improve impacted resources. Some of the most common grazing land practices include fence, water facilities, forage and biomass planting, herbaceous weed control, brush management, nutrient management, stream crossing, forage harvest management and prescribed grazing.

Technical information on NRCS conservation practices is available to the public in the NRCS electronic field office technical guide called the "e-fotg". Interested persons can find this information for the individual state by searching for NRCS in the state of interest and following the appropriate conservation practice links. For example; in Alabama search for "Alabama NRCS". The Alabama NRCS web page is also located at: <u>http://www.al.nrcs.usda.gov</u>. Persons may also log onto the national NRCS web page at: <u>www.nrcs.usda.gov</u>.

When the practices are properly implemented they can support a healthy management system. The land user can make an informed decision with the help of the planner to identify the resource concerns and how the conservation practices may help to resolve those concerns. Once the land user has identified the conservation practice to be implemented, a logical schedule for implementation can then be developed for the plan.

The land user must also understand basic operation and management strategies for the conservation practices chosen. Without such understanding, the chance of long-term success is minimized. Land users must understand how to maintain the selected conservation practices. All conservation practices need regular maintenance.

The land user must also consider weather extremes and the impact they can have in the agricultural world. Making contingency plans for those times when there is a lack of rainfall or too much rainfall will ease the management burden when the situation arises. For example, plans for dry weather could include: renting additional pastures, selling some of the livestock

herd to reduce feed demands, including native warm season grasses in the forage inventory for continued dry matter production, or buying more supplemental feed.

Key Points

Controlling erosion is important because it prevents the loss of valuable soil while helping to sustain a productive soil. Proper management and utilization of the natural resources will minimize erosion problems. In grazing systems:

- 1. Keep healthy stands of perennial forage;
- 2. Implement good grazing management to maintain a healthy forage plant;
- 3. A healthy forage plant favorably responds by producing more energy for root and leaf growth which leads to a healthier root system;
- 4. Healthy plant roots support soil biota that ultimately helps bind soil particles together;
- 5. Healthy plants also lead to increased coverage of the soil surface which reduces erosion;
- 6. Healthy plants also help to slow surface water runoff, reducing erosion;
- Utilize conservation practices to correct resource problems or improve management. Typical conservation practices include: Fence, Water facilities, Pipeline, Forage and Biomass Planting, Forage Harvest Management, Nutrient Management, Herbaceous Weed Control, Brush Management, Riparian Forest Buffer, Filter Strip, and Prescribed Grazing;
- 8. Use appropriate stocking rates and stocking densities as determined by analysis of the forage production compared with the animals' dry matter needs.

CHAPTER 13 STRATEGIES TO MANAGE PARASITES AND DISEASES OF GOATS UNDER GRAZING/BROWSING CONDITIONS

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Introduction

Internal parasitism is the most significant medical problem affecting animal goat health and production. Internal parasites are the most common cause of diarrhea, weight loss, anemia, poor production, poor reproduction, and general ill health in animals. The economic losses for producers of animals with high levels of internal parasites can be devastating. Internal parasites result in decreased milk and meat production and increased production costs (labor and drug costs). Overstocking of animals and the subsequent lack of available grass or browse leads to an increase in herd parasitism. The inappropriate use of dewormers leads to dewormer resistance and further severity of herd parasitism. Other problems such as infectious diseases (footrot, caseous lymphadenitis, some abortions) may also be prevented through good management practices and a rigorous herd health program. Developing a good relationship with local extension agents and veterinarians is integral for maintaining a healthy and productive herd.

Common Parasites Encountered in Goats on Pasture

Nematode Parasites (Roundworms)

Gastrointestinal nematode parasites of sheep and goats are similar to those of cattle; however, there is host specificity as cattle species do not readily infect sheep and goats and vice versa. The major gastrointestinal nematodes of sheep and goats are *Haemonchus contortus, Teladorsagia* (formerly *Ostertagia*) *cicumcincta, Trichostrongylus* spp. (usually *Trichostrongylus columbriformis, Cooperia curticei,* and *Oesophagostomum* spp. Other nemtadoes of minor clinical significance include *Nematodirus* spp., *Trichuris ovis, Bunostomum trigonocephalum, and Strongyloides papillosus* (Miller et al., 2012). The particular species that contribute to clinical disease vary based on geographic region and subsequent weather conditions. Most of the aforementioned nematode parasites affect the abomasum or small intestine. In a large portion of the United States, *Haemonchus contortus,* the barber pole worm is the most important nematode with respect to clinical disease and economic impact. Overstocked conditions, which lead to overgrazing of pastures and an increased rate of exposure to infective larvae, often predispose animals to severe parasite infections. Animals in overcrowded conditions are often malnourished due to inadequate nutrient and protein intake, and thus are more susceptible to infection by gastrointestinal parasites.

The life cycles for these nematodes are quite similar in that eggs are deposited by female parasites and are passed into the feces and hatch under favorable environmental conditions into

the first stage larvae (Fig. 13.1). The first stage larvae molt to the second stage and then the third stage, infective larvae. The third stage larvae migrate out of the feces when there is adequate moisture and carried by moisture up on the grass where they are then ingested by the host during grazing. Once ingested, the larvae molt to the fourth and fifth stage larvae (immature adult) which then develop into the reproductive mature adult to complete the life cycle. During unfavorable environmental conditions (winter cold or summer heat), the fourth stage may undergo arrested development in the stomach or small intestine and remain there until conditions are more favorable. Once conditions are more favorable, the fourth stage larvae resume their development (Miller et al., 2012).



the barber pole worm

Figure 13.1. Life cycle of *Haemonchus contortus*. Source: http://www.aragriculture.org/News/goat_sheep/2011/may_june2011.htm.

Each nematode parasite induces its own specific changes within the host. Virtually all animals are infected; although, many infected animals may show no visible signs of disease. Infection is normal; however, an excessive number of parasites cause pathology. When infections levels are high enough, signs of clinical disease may include the following: anemia, diarrhea, poor growth, weight loss, submandibular edema or bottle jaw, decreased milk production, and death. The clinical signs are dependent upon which parasite is most numerous. *Haemonchus contortus* creates the most significant clinical disease, anemia, typically without the presence of diarrhea unless there is a mixed infection.

Cestode Parasites (Tapeworms)

The most common cestode or tapeworm infection of goats in North America is due to *Moniezia* spp. Segments of *Moniezia* are visible in the feces, looking like a grain of rice, and thus may be a concern to owners. Small numbers of *Moniezia* may be of little clinical concern. Although, tapeworms may reduce the rate of gain and predispose kids to entertoxemia. A clinical syndrome has also been described that is characterized by inappetence and rupture of the gut has been

identified when large numbers of *Moniezia* are present in young animals (Miller et al., 2012). Tapeworm life cycle is shown in Figure 13.2.



Figure 13.2. Tapeworm life cycle in sheep. http://www.farmanimalhealth.co.uk/sheep-worms.

Trematode Parasite (The Liver Fluke)

Both of the liver flukes *Fasciola hepatica* and *Fasciola magna* can infect goats. Liver flukes are restricted in their geographic distribution due to the reliance on a specific snail as an intermediate host that lives only in specific aquatic or semiaquatic environments and soil types. The liver fluke life cycle is shown in Figure 13.3. These trematode parasites are common in the Gulf Coast, Pacific Northwest, and Great Lakes regions of the United States. The liver fluke migrates from the small intestines to the liver and bile ducts where the parasite can live for years if left untreated. The liver flukes also leave tracts of scar tissue. In sheep, one of the most severe consequences of acute liver fluke infection is black disease (due to *Clostridium novyi* infection) which causes acute death. Although uncommon, black disease may also occur in goats as well. Thus, vaccination against *Clostridium novyi* is important in areas where there is risk of fluke-associated disease. Acute disease conditions are due to the migration of immature liver flukes through the liver. Clinical signs of disease include inappetence, depression, weakness, difficulty breathing, anemia, signs of colic, and sudden death. Chronic disease is due to the presence of immature flukes in the bile ducts and is seen as decreased growth and milk production (Miller et al., 2012).



Figure 13.3. Life cycle of liver fluke. Source: http://www.goatbiology.com/parasites.html.

Finding eggs in the feces is diagnostic for *F. hepatica.* Eggs are not produced in great numbers so a negative fecal test result cannot rule out infection. Fluke eggs do not float in routine fecal flotation; thus, a sedimentation technique must be used. Infection is often discovered at slaughter or necropsy. Flukicides are available for treatment but are only effective against mature flukes. Therefore, the timing of treatment is important. In the southern United States, treatment is recommended in late summer or early fall after the flukes migrate and mature in the late spring and summer. Ivermectin products that contain an adulticidal dose of clorsulon are available but are not approved for use in sheep or goats. Albendazole has also been used to against flukes. Control of fluke infections is difficult, but decreasing exposure is the key. Properly timed treatments and fencing off low-lying wet areas or avoiding grazing high risk areas may be beneficial (Miller et al., 2012).

Coccidia

The most common cause of diarrhea in young kids, 1 to 6 months of age, is coccidiosis which is caused by *Eimeria* spp. Coccidioisis is most commonly associated with stressful conditions such as weaning, feeding changes, or shipping. Crowded conditions with excess manure create favorable conditions for transmission. Animals may exhibit severe, watery diarrhea, inappetence, dehydration, weakness, rough hair coat, weight loss, and death. Coccidiosis may be diagnosed via demonstration of the oocysts on routine fecal flotation. However, diagnosis can be difficult because clinical disease and death may occur before oocysts appear in the feces (2 weeks after infection). Almost all goats shed coccidion in the feces. Animals with diarrhea and a history of stress should be treated for coccidiosis.

Treatment includes supportive care (fluid and nutritional support) and the administration of anticoccidial drugs. Many coccidiostats are used prophylactically when conditions are favorable for coccidiosis (stressful situations). The most important factor in the prevention of coccidiosis is the prevention of fecal-oral contamination. Control measures include improved management and

sanitation. Preventing overstocking, minimizing stress, and providing optimal nutrition are key to managing coccidiosis.

Parasite Control Programs

Decision Analysis for Use of Dewormers

In order to understand which dewormer(s) will be effective in a particular animal or farm, it is important to know 1) which parasite (s) are causing clinical disease on the farm, 2) the deworming history of the animal and the farm, and 3) which dewormers have been effective in the geographical area. Your local veterinarian can be a very valuable resource as a member of your parasite control program. Your veterinarian can perform thorough physical examinations to identify any underlying physical conditions, fecal examinations (flotation, McMaster Egg Count) to identify which parasites are present and the severity of infection, make treatment recommendations, and provide meat and milk withdrawal times. There are very few dewormers that are approved for use in small ruminants; those that are approved are labeled for use in sheep, not goats. The Food and Drug Administration does allow limited extra-label use of dewormers in goats is only permitted, legally, when a bona fide veterinarian-client-patient relationship exists and an appropriate medical diagnosis is made. Therefore, it is very important to establish a relationship with your local veterinarian so that you may have a reliable ally to consult with regard to your parasite control program (Miller et al., 2012).

Complete Herd Deworming

Over the past few decades, traditional approaches to parasite control have been based on deworming all of the animals in the herd. After deworming, the small number of parasites that remain will have little or no noticeable effect on animal health and production until approximately 25 percent of the worm population is resistant to the drug used. The continuous use of the same dewormer (or members of its class) in a herd where all animals in the herd are being dewormed will, over time, result in a population of nematodes that are resistant to that particular class of dewormers. In addition, the rotation of dewormers does not prevent dewormer resistance either. A complete herd deworming program selects for resistant nematodes and is not advised.

Targeted Selective Deworming

Nematode infections are not distributed evenly in the herd. Only 30 percent of animals in the herd harbor a majority of the nematodes and thus are responsible for the majority of pasture contamination; 30 percent of the animals in the herd harbor 70 percent of the parasites. Since resistance to dewormers is genetically based, it is important to make sure that there is a population of susceptible nematodes in order to extend the life of dewormers that are effective. In order to preserve dewormer efficacy, it is necessary to leave some animals untreated. This is known as targeted selective treatment. This type of approach should help ensure that a refugium (portion of nematode population not treated) of susceptible nematode larvae (from non-treated animals) is maintained on the pasture to help dilute out resistant genes from resistant nematodes that survived treatment. The success of this method is in part due to the use of the FAMACHA

system to identify anemic animals needing deworming. Thus, non-anemic animals are not dewormed and provide the refugium (Miller et al., 2012).

Fecal Examination, Equipment Required for Fecal Examination

Diagnosis of gastrointestinal nematode infections is usually made by microscopic examination of the feces for nematode eggs. Quantification by performing fecal egg counts (FEC) using the Modified McMaster Egg Count is the best method to estimate parasite burdens. Fecal parasite egg examination methods are based on differences in density. Parasite eggs sink in water but will float in solutions that are denser than water because the eggs are lighter than the fluid used as a flotation solution.

Materials that are needed to perform a Modified McMaster Egg Count for quantification of nematode eggs include the following: compound microscope, scale, saturated sodium chloride solution (see Appendix 2), 50mL centrifuge tube with screw cap marked in 1mL increments, tongue depressor, pipette (or 1mL syringe or eye dropper, McMaster egg counting slide (Chalex Corporation, Wallowa, OR), paper towels, and a fresh fecal sample (refrigerate until tested). Please see Appendix 2 for the procedure for the Modified McMaster Egg Counting for Quantification of Nematode Eggs (Miller et al., 2012).

FAMACHA

It is necessary to leave some animals untreated as this will ensure that a refugium (a portion of the worm population that is not selected by anthelmintic treatment) of susceptible parasite larvae (from non-treated animals) is maintained on pasture. This susceptible population will help dilute out resistant genes from resistant nematodes that survived treatment. The FAMACHA system helps identify anemic animals that need deworming. The non-anemic animals remain untreated and provide the refugium. The FAMACHA system has been used successfully in areas where H. contortus was the primary nematode. The FAMACHA system reduces the number of deworming treatments while slowing the development of resistance to dewormers and still allowing farmers to maintain good parasite control. The level of anemia is determined by evaluating the color of the lower eyelid and comparing the color to an anemia guide that is provided on a laminated card (Fig. 13.4). Adult animals are evaluated at 2 week intervals and are assigned a grade from 1 to 5 (grade 1 has red eye lid color, grade 5 has white eye lid color) based on their level of anemia. Animals that are grades 5, 4, and possibly 3 would be at risk and would need to be treated. Animals that need multiple treatments should be culled from the herd (Miller et al., 2012). Formal training on how to effectively use the FAMACHA system is available through veterinarians and through the Southern Consortium of Small Ruminant Parasite Control (SCSRPC; www. scsrpc.org).



Figure 13.4. FAMACHA card. Source: http://www.jackmauldin.com/refugia_7.htm.

Anthelmintics and Their Use: Classes of Deworming Products

Benzimidazoles (thiabendazole, fenbendazole, albendazole) belong to the one class of broad spectrum anthelmintics introduced; resistance to all drugs in this class has been documented. In general, resistance to one drug in a class confers resistance to all drugs in the class (side resistance). Benzimidazole resistant parasites do not reacquire susceptibility, even after many years of withholding the use of these drugs. Efficacy of benzimidazoles may be improved somewhat by increasing dosages, dividing dosages into two treatments administered 12 hours apart, and fasting animals prior to treatment. By fasting the animal for at least 24 hours prior to treatment, the rate of passage of ingesta down the gastrointestinal tract is reduced so that the anthelmintic stays in the system longer with increased contact time with the parasites. However, sick, debilitated, and pregnant animals should not be fasted.

Imidazolthiazoles and *tetrahydropyrimidines* (levamisole, morantel tartrate, and pyrantel pamoate) belong to the second class of broad spectrum anthelmintics. Resistance is not as prevalent or as widespread as with the benzimidazoles; this may be in part due to a lower frequency of use. Cross resistance occurs in this class as well. However, a few reports indicate that once resistance has been established, temporary reversion to susceptibility may occur if the parasites have not been exposed to these anthelmintics for several years; although, long-term, true reversion has not been demonstrated. The class of dewormers has the lowest margin of safety so toxicity may occur with inaccurate dosing.

Macrocyclic lactones (ivermectin, moxidectin) belong to a newer class of broad spectrum anthelmintics. Resistance to these drugs, especially ivermectin, is now widespread. Moxidectin has been approved for use in sheep (but not goats) in the United States, and when first used it is effective in areas where ivermectin resistance is seen. Cross resistance is still a problem, and ivermectin resistant parasites can rapidly become moxidectin resistant if moxidectin is used frequently. Therefore, moxidectin should be used cautiously, and its selection as a first choice drug is not recommended until all other anthelmintics have failed. It is also recommended that the practice of injecting or using pour-on products designed for cattle not be used in small ruminants; this practice may increase the development of resistance due to inappropriately low
drug absorption (pour-on use) or long-term subtherapeutic levels (with injection) (Miller et al., 2012). When dewormer resistance is noted on a farm, the use of more than dewormer (combination deworming) may be beneficial. Again, care should be taken to avoid overdosing and overuse of dewormers.

Monepantel (Zolvix[®]) is a drug representing a new class of anthelmintics that is currently being marketed in New Zealand. It is not currently approved for use in North America. It is important to remember that as new dewormers make their way to the U.S. market, that the parasites will eventually develop resistance. Therefore, all dewormers should be used carefully to help avoid resistance.

Management Practices for Parasite Control

Pasture management

Pasture rotation is used primarily to provide grazing animals with the most nutritious forage. The period for most forages to recover from grazing to once again reach a nutritious stage and maintain plant sustainability is approximately 30 days; therefore, this rotation interval is common. However, peak pasture infection occurs at approximately 15 days after pellets fall to the ground, assuming warm and moist conditions thus creating a high level of larval contamination of pasture for the next grazing group. This rotational practice may actually lead to increased parasite infection. There is evidence that suggests that pasture infectivity can be reduced in tropical and subtropical environments with rotation at 1.5 to 2 month intervals because the larvae are relatively short-lived under hot environmental conditions. However, rotating at this interval is impractical for efficient forage utilization. In more temperate environments, pasture infectivity can extend out to eight to twelve months, so rotation is of little use in controlling parasites. Leaving pastures ungrazed for such extended periods may not be practical unless the pastures are to be cut for hay. An important factor to consider is that stocking rates are often higher than normal with rotation schemes which leads to increased fecal and larval contamination. It is also important to rotate pastures so that the grass or forage height is never less than four to five inches in height for goats (larvae are concentrated in lower 2-3 inches of the grass) in order to minimize parasite infection. This is important because the infective larvae are unable to migrate higher than two inches up a blade of grass (Miller et al., 2012).

Some condensed tannin-containing plants have been found to reduce fecal egg counts (FECs). In the United States, sericea lespedeza (*Lespedeza cuneata*) is a perennial warm season condensed tannin-containing legume that can be grazed or fed as hay or pellets to control *H. contortus*. When sericea lespedeza is grazed, up to four weeks may be required for the animals to acclimate to eating it. If it is being fed as a supplement (hay or pellets), the animal's total intake of sericea lespedeza needs to be around 50 percent or higher. Other plants containing tannins, such as chicory and sainfoin, have also shown to be effective. This may offer a very good natural method for parasite control. Because many condensed tannin-containing plants are browse and some are legumes, other potential benefits include consuming forage off of the ground at a high forage height (to reduce parasite exposure) and increasing protein intake (to enhance the ability of the animal to handle ongoing infections and resist future infections) (Miller et al., 2012).

Dietary Management of Parasites

The nutritional status of the host can have an important influence on the effects of parasitic infection. Animals on a good plane of nutrition are better able to withstand parasite infections than animals on an inadequate diet. Nutrition plays a role in both the host's ability to deal with the infection and the ability to resist becoming infected. An animal receiving an adequate level of nutrition can more effectively deal with the negative consequences of a parasitic infection. An animal's ability to resist parasite infection is related to the immune status of the animal; the immune system/response has a high requirement for protein. Inadequate nutrition can thus lead to an inadequate immune response and higher levels of infection. It is important to remember that no matter how well an animal is fed, increasing infection levels may eventually reach a point at which parasitism overwhelms the host's ability to function properly.

Nutrients are absorbed from the gut and are partitioned to where they are most needed (for growth, breeding, pregnancy, lactation, immunity). Some nematode parasites cause damage to the tissue of the gut and can, thus, compromise nutrient absorption. In addition, parasites cause loss of protein through the gut. Therefore if protein is less available, immune function is impaired and animals become more susceptible to subsequent infection. Inadequate feeding will result in loss of productivity and an increased risk of parasitic disease. Increased dietary protein appears to maximize both the animal's ability to deal with the infection and the ability to resist becoming infected. Dietary supplementation (protein, energy, minerals, and vitamins) appears to be most beneficial in times of natural weight or body condition loss and increased nutrient demands (late gestation, parturition, early lactation) and most effective when a quality diet is used. Optimizing the overall health of the animal through the feeding of adequate energy, appropriate mineral intake, and adequate access to browse is extremely important in parasite control programs (Miller et al., 2012).

Common Diseases Encountered in Goats on Pasture

Footrot

Infectious footrot is a contagious disease of goats that leads to significant economic losses as a result of weight loss, labor and treatment costs, decreased milk production, and premature culling. The primary agent is the anaerobic bacterium *Dichelobacter nodosus*. Previous infection with the bacterium *Fusobacterium necrophorum* contributes to the development of footrot. Footrot occurs in areas of extreme warmth and wetness. The spring and fall are the times when transmission is most likely. The source of infection is the feet of infected animals (including chronically infected carriers) which transmit the organism to the soil where it contacts the feet of other animals. The organism can only survive a few days to a few weeks in the environment but can persist for years in carrier goats. New infections usually are preceded by the introduction of new animals or exposure to ground that has recently been occupied by infected animals. Management practices that allow the concentration of animals in small areas, irrigated pastures, long grass (which may abrade the interdigital skin), and wet or rainy conditions all predispose to infection (Reilly et al., 2012).

Footrot is characterized by swelling and necrosis of the space between the claws. Affected areas produce a foul smelling discharge. The animal may carry the affected leg, graze on the knees, or

lay down. The treatment for footrot involves proper hoof trimming, antibacterial agents (antibiotics and antiseptics) applied topically to the foot, and systemic antibiotics. Prevention of footrot can be achieved by doing the following: 1) separate infected animals and disinfect trimming equipment between animals, 2) move all animals through a foot bath, 3) move animals to a clean pasture, 4) cull all severely affected animals and those not responding to treatment, 5) vaccination (injection site reactions are common), and 6) selectively breed for animals that appear to be less susceptible (Reilly et al., 2012).

Clostridial Diseases

Clostridium species are anaerobic bacteria that produce spores which may be the only viable form in the soil. Clostridia inhabit the intestinal tract and are present in the feces of many healthy animals. This bacterium can be found in the soil but is thought to have a short life span in the soil. Soil concentrations are highest in areas recently contaminated with ruminant feces, especially crowded, overused facilities such as feedlots and kidding sheds. Environmental contaminations are associated with cool, damp times of the year (late winter and spring).

Clostridium perfringens type C causes a disease called hemorrhagic enterotoxemia in kids younger than 3 days of age. Fecal contamination of teats, hands, and equipment allows for the agent to enter the mouths of neonates and establish infection. Severely affected animals or those at the beginning of the outbreak are usually found dead. Other animals will have a yellow-colored to hemorrhagic diarrhea that may contain flecks of blood, have a painful abdomen, show signs of colic (teeth grinding and vocalization), and refuse feed. This disease is almost always fatal. *Clostridium perfringens* type D (enterotoxemia, overeating disease) causes hemorrhagic enterocolitis and tends to occur in animals after over ingestion of high-energy feeds (milk, grain, lush pasture) or animals that have experienced a recent change in feed.

This disease usually happens to the fastest-growing and most well-conditioned animals. Goats develop severe enteritis and become toxic as a result of toxins produced by the bacteria circulating in the blood. Usually this condition is not recognized until the animal is dead or dying. Routine vaccination should start at 4 to 6 weeks of age and should be followed by a booster 3 to 4 weeks later. In areas where the disease in common, kids can be vaccinated and given antitoxin during the first week of life. Yearly or annual vaccination, preferably 3 to 4 weeks before the does give birth, improves colostral immunity in the kids. Vaccination of only *C. perfringens* type C and type D vaccines and tetanus toxoid ("CD&T") is superior to the use of the 7 and 8 way clostridial vaccines. Reducing the energy in the diet and avoiding sudden dietary changes or alterations in the feeding routine are crucial to prevent this disease in this group of animals (Cebra and Cebra, 2012).

Skin Diseases

Contagious ecthyma (Sore Mouth, Orf, Contagious Pustular Dermatitis) is a viral skin disease that is transmitted by direct contact with affected animals, objects that have been contaminated by affected animals, or by contact with scabs or contaminated soil. The virus enters through a break in the skin. This is a very important zoonotic skin disease and is extremely painful when humans are infected. Humans should take precautions to avoid exposure by wearing disposable gloves for treatment or examination in suspected cases. Affected animals have with scab-like

lesions on the lips, muzzle, and in the mouth. Lesions appear as crusty proliferations, similar to fever blisters. Painful lesions may also develop on the teats and udder of nursing dams as a result of suckling of affected kids; this may lead to refusal of the affected dam to nurse her offspring. The doe may have to be held for several days to allow the kid(s) to nurse. Treatment of contagious ecthyma is seldom attempted because the disease is self-limiting and should resolve within 3 weeks; supplemental feedings may be required especially for young kids. Prevention is best achieved by preventing the disease from entering the farm through quarantine and physical examination of stock entering the farm, by minimizing stress and by purchasing stock from contagious ecthyma-free herds. Contact with suspect animals at livestock shows and sales should be avoided as well as use of common feed, water, and grooming equipment. In an outbreak, the affected animals should be isolated and the remainder of the does that are close to kidding may be vaccinated (Roberson et al., 2012). Otherwise the disease should be allowed to run its course.

Dermatophilosis (Rain Scald, Rain Rot) is a skin disease that is caused by the bacterium *Dermatophilus congolensis*. This bacterium appears to be maintained within herds by carrier animals, and skin damage (biting insects or physical abrasions) may predispose to infection. In goat kids, lesions tend to be on the ears and tails; in adults, lesions tend to be present on the muzzle, the top of the back, scrotum, or lower legs. Treatment consists of either topical antiseptics or systemic antibiotics). *Dermatophilus* is potentially zoonotic or transmissible to humans (Roberson et al., 2012).

Caseous lymphadenitis is a common, contagious disease of goats that infects the lymph nodes. This disease is caused by the bacterium, *Corynebacterium pseudotuberculosis*. The bacterium enters the body through the skin or mouth by inhalation or ingestion. Once a lymph node becomes infected, an abscess is formed and is spread to other lymph nodes and internal organs. Abscesses tend to contain very thick exudate. This organism survives for months in the environment, and environmental exposure, especially from contaminated instruments (halters, clippers), troughs, etc. This disease is considered zoonotic. Animals with caseous lymphadenitis exhibit enlarged lymph nodes, particularly the lymph nodes around the head, neck and mammary glands. Although not visible, internal lymph nodes and organs can also be infected and lead to eventual death.

Goats with internal abscesses typically have a history of chronic weight loss, but coughing and respiratory problems may also be seen if the abscesses are associated with the lungs. Any enlarged lymph nodes should be presumed to be caseous lymphadenitis until proven otherwise. Because the abscess material is potentially highly contagious, special care should be taken to keep the exudate or abscess material from reaching the environment. External lymph node abscesses can be surgically removed but care must be taken to ensure that the abscess does not contaminate the environment. Isolation of infected animals for at least one month is recommended to prevent spread to other animals. Following infection, animals should only return to the herd after they have been free of any clinical signs of disease for one month. However, this is still a risky management practice as this animal may remain a potential source of infection to the remainder of the herd. If an abscess ruptures, care should be taken to ensure that all abscess material and contaminated materials should be burned. Systemic antibiotics are not considered very effective because of their inability to penetrate through the thick wall of the abscessed lymph node.

If only a small number of animals are affected, the most cost effective treatment of caseous lymphadenitis is to cull the affected animal as this prevents potential spread to other animals. The best prevention is to maintain a caseous lymphadenitis-free herd. Any new animals should be quarantined and tested for the disease and examined for lymph node enlargement before entering the herd. Housing should be maintained free of objects that can cause skin injury. Needles, tattoo pliers, shears, hoof trimmers, and other instruments should be cleansed and disinfected after use. Eradication of caseous lymphadenitis is possible but difficult in that it requires frequent testing and management of a disease-free group and an infected group. Vaccines are available and may be useful for producers who choose to live with the disease in that vaccination can reduce the incidence of abscesses in the herd. Vaccines do not necessarily prevent the disease. Goats that are vaccinated with the sheep vaccine tend to experience adverse reactions more frequently than do sheep. Reports indicate that goat owners are more satisfied with vaccines that are created from individual animals within a herd (autogenous vaccine) (Roberson et al., 2012).

Abortive Diseases

Abortion is the loss of the fetus at any time during gestation, but the loss is most commonly detected in the final two months. Abortion may be associated with infectious agents, toxicities, metabolic diseases, nutritional deficiencies, and stress. Clinical signs of abortion include early return to heat (early embryonic death) or presence of a blood-tinged vaginal discharge. The doe has a high incidence of abortion compared to other farm animals. Abortion rates of five percent are common. Energy, protein, mineral, and vitamin deficiencies may be responsible for abortion. Fetal loss due to nutritional deficiencies most commonly occurs between 90 and 120 days of gestation. Increasing dietary protein supplementation and providing mineral and vitamin supplementation to grass fed goats may reduce abortions. Maintaining optimal body condition scores (BCS), ensuring adequate protein intake, and supplementing the diet with a good quality, complete trace mineral mixture offered on a free choice basis may be protective. Ideally, the majority of does in a herd should have a BCS of 2.5 to 3 at breeding and parturition (where 1 is assigned to extremely thin animals and a BCS of 5 to those that are extremely obese).

Overweight or extremely thin does may be prone to a metabolic condition known as pregnancy toxemia. Although death of the doe is the usual outcome in cases of pregnancy toxemia, abortions may be observed in late-stage disease. Some plants may also cause abortion in does when consumed in sufficient quantities. The best method for preventing abortion due to the ingestion of toxic plants is to ensure that adequate forage and supplemental grain is being fed to pregnant does. Various medications have also been associated with abortion in goats. Dewormers such as phenothiazine, albendazole and levamisole given during gestation have been reported to cause abortion. The use of some sedatives (xylazine, acepromazine) may also cause abortion due to their adverse effects on uterine contraction and placental blood flow. Administration of corticosteroids in late pregnancy and estrogen and prostaglandins throughout most of gestation may induce abortion. Stress due to handling may also lead to abortion as well (Edmondson et al., 2012).

Abortions may also be caused by infectious agents such as bacteria, viruses, fungi, and protozoa. Some of the most common infectious causes of abortion include *Campylobacter fetus*, *Campylobacter jejuni*, *Chlamydophila abortus*, *Coxiella burnetii* (Q fever), *Brucella melitensis*, *Listeria* spp. and *Toxoplasma gondii*. It is important to remember that many infectious causes of abortion are zoonotic or can infect humans. Therefore, one must take care when handling animals and materials from an abortion. In the event of an abortion, the fetus and placenta, if possible, should always be submitted for necropsy to determine the potential cause of abortion (Edmondson et al., 2012).

Disease Prevention

The aim of a herd health program is to improve the overall health and welfare of the goats in the herd, decrease losses from disease, increase productivity, and maximize profitability. Prevention of common diseases may be accomplished through the use of appropriate vaccination schedules, minimizing risk factors for disease occurrence, appropriate levels of nutrition for stage of production, and assessment of metabolic status. Biosecurity programs are a critical element in the control of infectious disease by reducing the possibility of introduction of a new disease from an external source or by reducing the spread of infectious disease already on the farm. Biosecurity measures that should be promoted include the following: 1) purchasing animals directly from the farm of origin, 2) transporting animals in clean, disinfected transport vehicles, 3) housing animals in true isolation facilities for at least one month, and 4) performing regular observation of animals to look for signs of illness (pruritus, lameness, external lumps or swellings, coughing, anorexia, or unexplained weight loss). In addition, isolated goats should be tested for diseases of concern, integrated into the herd's regular vaccination program, dewormed with an effective anthelmintic or dewormer (as confirmed by fecal egg count), and have their feet trimmed and visually inspected for footrot.

Management Practices for Disease Prevention

Producers should adhere to strict biosecurity practices at the farm. Animals with apparent disease should not be transported to the farm or to shows or markets. Newly purchased animals or any animals that have left the farm (livestock show, veterinary care/hospitalization, etc.) should be isolated or quarantined from all other animals on the farm for at least four weeks. There should be no contact between new animals and the resident herd animals during this quarantine period. Maintaining a closed herd and purchasing new animals from known sources is also encouraged. Access to the farm should also be restricted by posting signs for vehicle and foot traffic control. If visiting a livestock market, show, etc. then one should wear different shoes and clothing and change before working with livestock. Animals in quarantine should be provided with good nutrition (water, feed, and minerals) and vaccinated and dewormed according to the farm's herd health program (Scharko et al., 2012).

Vaccination Programs for Disease Prevention

Through regular and correct usage, vaccines are designed to reduce the incidence and severity of a specific disease. It is important to remember that no vaccine is 100 percent efficacious in preventing disease. However, when vaccines are used appropriately, they can serve to maximize protection of animals. Local veterinarians can provide advice on what diseases are a concern regionally and recommend appropriate vaccinations accordingly. Vaccination should be used according to the label directions because the timing of doses is crucial to optimal protection. Clostridial diseases are the only universal group of diseases for which all goats should be vaccinated against. Decisions regarding the inclusion of other vaccines in an individual herd

health program should be based on knowledge of prevalent diseases in the area and the needs of a particular herd. Goats that are frequently exhibited (shows, FFA, or 4H) are at greater risk for contracting contagious and infectious diseases. For this reason, show goats may need to be vaccinated against more diseases than is usual for goats in a closed herd. It is important to remember that there are no vaccines labeled for use in goats. Therefore, it is imperative to consult your veterinarian to ensure proper dosage, adherence to appropriate withdrawal periods, and safety of the animals (Scharko et al., 2012).

Hands-on Activities

- 1. Demonstration of examination and vaccinations, injection of medication for a goat, injection sites.
- 2. Demonstration of FAMACHA for a goat.
- 3. Demonstration for collection and examination of fecal sample including fecal egg count for parasite determination and quantification.

Key Points

- 1. Internal parasitism of goats is the most significant medical problem affecting animal health and production. Overstocking of animals and lack of available grass or browse leads to an increase in herd parasitism. The inappropriate use of dewormers leads to parasite resistance and further severity of herd parasitism.
- 2. Infectious diseases such as footrot, dermatophilosis, caseous lymphadenitis, and clostridial diseases are also common in goats. These conditions can usually be successfully treated and prevented or minimized with changes in management and with the implementation of a robust herd health program (quarantine, vaccination, etc.).
- 3. Since almost all of the medications and vaccines that are used in goats are considered extra-label (not labeled for use in goats), veterinarians are <u>required</u> to have valid veterinarian/client/patient relationship before they are allowed to prescribe any medication to a goat. Therefore, developing a good relationship with local extension agents and veterinarians is integral for maintaining a healthy and productive herd.

References

- Cebra, C. and M. Cebra. 2012. Diseases of the hematologic, immunologic, and lymphatic systems (multisystem diseases). In: D. G. Pugh and A. N. Baird, editors, Sheep and goat medicine. Saunders, Maryland Heights, MO. p.466-502.
- Edmondson, M. A., J. F. Roberts, A. N. Baird, S. Bychawski, and D. G. Pugh. 2012. Theriogenology of sheep and goats. In: D. G. Pugh and A. N. Baird, editors, Sheep and goat medicine. Saunders, Maryland Heights, MO. p.150-230.
- Miller, J. E., R. M. Kaplan, and D. G. Pugh. 2012. Internal parasites. In: D. G. Pugh and A. N. Baird, editors, Sheep and goat medicine. Saunders, Maryland Heights, MO. p.106-125.
- Reilly, L. K., A. N. Baird, and D.G. Pugh. 2012. Diseases of the musculoskeletal system. In: D. G. Pugh and A. N. Baird, editors, Sheep and goat medicine. Saunders, Maryland Heights, MO. p.291-324.

- Roberson, J. R., A. N. Baird, and D. G. Pugh. 2012. Diseases of the integumentary system. In: D. G. Pugh and A. N. Baird, editors, Sheep and goat medicine. Saunders, Maryland Heights, MO. p.256-290.
- Scharko, P., J. Johnson, S. Mobini, and D. G. Pugh. 2012. Flock and herd health. In: D. G. Pugh and A. N. Baird, editors, Sheep and goat medicine. Saunders, Maryland Heights, MO. p.539-556.

CHAPTER 14 THE ECONOMICS OF YEAR-ROUND FORAGE PRODUCTION AND GRAZING/BROWSING MANAGEMENT

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Introduction

It is a well-known fact and a challenge to most goat producers, specifically, small scale and limited resource farmers to sustain goat farming because of high feed costs. However, it may not hold true to generalize the situation as what works for one producer in one location may not work for another producer in other location. Undoubtedly, ever increasing price of grains, concentrate, and hay has positioned goat farming economically vulnerable. One of the most economical ways to make profits from goats would be by improving pastures and allowing goats for as much grazing as possible throughout the year. For this to happen, producers have to critically examine the economic and ecological benefits of the Year-Round Forage Production (YRFP) technology, and introduce the technology for making goat enterprise sustainable. According to Luginbuhl (2006), meat goats do not fatten like cattle or sheep because of their unique physiology, and rates of weight gain are smaller, ranging from 0.1 to 0.8 pounds per day. Therefore, profitable meat goat production can be achieved by optimizing the use of high quality forage and browse, and the limited, strategic use of expensive concentrate feeds. Below is the list of few strategies to maximize the profit margin.

Strategies to increase the profit margin

- Use body condition score to determine the feeding scheme. Condition score can be an indication of whether you are overfeeding or underfeeding your goats.
- Generally, legume hays tend to cost more than grass hays. It is a waste of money to feed legume hays/high quality forages to goats that do not have high nutritional requirements. So, it is important to feed the right forage at the right time to the right group of animals.
- Divide your goats into production groups and apply least-cost rations according to their nutritional requirements when supplementary feeding is needed.
- Use feeders to feed hay and concentrate to minimize the wastage of feed and reduce the likelihood of spreading diseases.
- Explore alternative, cheaper feedstuffs to substitute more expensive energy and protein source.
- Feeding cost is one of the major costs involved in goat production. Therefore, it is important to select most productive and least problematic animals to continue the herd and cull unproductive animals.

• Develop strategies for capitalizing on opportunities available in your farm (intensive use of your land, plantation of cool- and warm-season forages, implementation of sustainable grazing, and adoption of economies of scale for optimum production).

Record Keeping

Record keeping is one of the most important activities in farm business management. It is the process of capturing data or translating pieces of information into a recording format, which is often referred to as a record. Data are values of qualitative (such as breed, sex, and color) or quantitative (such as birth weight, weaning weight, and milk production) variables belonging to a set of farm animals. These also involve economic values such as production costs and incomes associated with the farm. Required data should be collected in a systematic manner such that one can use these for calculating costs and incomes, preparing a report on the performance of the farm, determining the strengths and weaknesses of the farm, and making many other decisions regarding farm planning and budgeting. A good record is very essential to continuously maintain and improve a farm.

Why Do We Maintain Records?

Maintaining records is necessary to keep data of inputs and outputs that are required for analyzing economic soundness of the farm, and animal performance information to be able to select the best and cull the least performing animals to continuously build a good herd. Moreover, one can also record physical, social, and psychological benefits and improvement in land productivity. Broadly we can categorize records into: i) physical farm records (land utilization, forage and pasture production, goat production and disposal, labor and machinery uses, feed, stock, etc.), ii) financial record (farm inventory, farm cash/financial accounts, sale/receipts, purchase, wage, funds borrowed and repayments, farm expenses (in kind), etc.). Memorizing all these details for a long time is not possible. A good record is the basis for calculating how the business/farm/enterprise is performing over time, such as the economic status of the farm enterprises: profit, loss, break-even, economic sustainability, comparative advantage, opportunity cost, and gross and net margins of the farm activities. Some of the advantages of keeping systematic records can be described as: i) means to obtain higher income; ii) basis for diagnosis and planning; iii) way to improve managerial ability of the farmers; iv) basis for credit acquisition and management. Additionally, a well-kept record can be very useful while filing taxes.

Production Costs

Production costs are all different types of costs involved in the process of producing a desired product. A farm manager or producer needs to be familiarized with these costs in order to do economic analyses and make economically sound decisions. Major categories of costs that are involved in simple economic calculations are briefly discussed below.

Fixed cost: Fixed costs are the expenses that are not directly applicable to each animal but are incurred by the farm whether or not any animals are produced or sold. These costs must be paid

even if no output is produced e.g., taxes, insurance, operator labor, interest, and/or depreciation on farm equipment and machinery.

Variable/running cost: Unlike fixed costs, variable costs vary depending on number of goats raised in a farm. For example, as the number of goats increases in the farm, the costs for feeding, health care, and labor increase, and vice versa.

Total Cost: Total cost involves all the costs associated with the operation of an enterprise, and can be calculated as the sum of fixed costs (FC) and variable costs (VC) (Fig. 14.1).



Opportunity cost: It is the cost of any activity measured in terms of the value of the next best alternative forgone (that is not chosen). In other word, it is the sacrifice related to the second best choice available to someone or a group, which has been picked among several mutually exclusive choices. The opportunity cost is also the "cost" (as a lost benefit) of the forgone products after making a choice.

Overhead expense/cost: It refers to an ongoing expense of operating a business, and also known as an "operating expense". Examples include rent, gas, electricity, taxes, telephone bills, travel expenditures, and wages.

Profit Maximization

Profit maximization is the process by which a farm determines the price and output level that returns the greatest profit based on the available resources. **Profit** is the difference between revenue (R) and the cost (C), each of which is defined below.

- Revenue = quantity of output times price per unit of output.
- Cost = quantity of input times price per unit of input.

Major Approaches of Profit Maximization

i) Total revenue (TR) vs. Total cost (TC) Approach: This approach focuses on maximizing the difference between TR and TC; economic profit is maximized where TR exceeds TC by the greatest amount or the largest difference.

Golden rules of profit maximization in this approach are listed below:

• Expand output as long as TR > TC

- Stop production when TC > TR
- ii) Marginal cost (MC) = Marginal revenue (MR) Approach: To maximize profit or minimize loss, a farm should produce the quantity of output at which marginal cost equals marginal revenue; this rule holds for all market structures.

Golden rules of profit maximization in this approach are listed below:

- Expand output as long as MR > MC
- Stop production before MC > MR

Relationship between Demand/Supply and Price

i) Quantity demand and price of goat meat: The market demand curve (D) shows the quantity





of goat meat demanded, at various prices, by all consumers (Figure 14.2). Price and quantity demand are inversely related. In other words, the higher the price, the lower the quantity demanded.

Figure 14.2. The relationship between price and quantity demanded. Source: Adapted from McEachern, 2009.

ii) Quantity supply and price of goat meat: Market supply curve S shows the quantity of goat meat supplied, at various prices, by all goat producers (Fig. 14.3). Price and quantity supplied are directly related. In other words, the higher the price, the higher the quantity supplied.

Figure 14.3. Relationship between price and quantity supplied. Source: Adapted from McEachern, 2009.

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Basics of Farm Production Functions and Decisions

Production function is the relationship between the amount of resources employed and the total product of a farm. With demand, we assume that consumers try to maximize utility, a goal that motivates their behavior. With supply, we assume that producers try to maximize profit, and this goal motivates their behavior. The production of goods and services involves different kinds of inputs or factors of production, such as labor, capital, land, and entrepreneurial ability, each of which is briefly defined below.

- Labor is the physical and mental effort used to produce goods and services.
- **Capital** is a factor of production that is not wanted for itself but for its ability to help in producing, procuring, or developing other goods, such as buildings, equipment, and human skills used to produce goods and services.
- **Natural resources** are all gifts of nature, such as land, water, trees, and even animals used to produce goods and services.
- Entrepreneurial ability is the talent required to develop a new product or process and/or an ability to find a better way to produce an existing one. In other word, it is the skill needed to organize production and the willingness to take the risk of profit or loss. An entrepreneur is a profit-seeking decision maker.

A producer or farm manager should exercise their knowledge and skills to minimize the costs of production and maximize profits. One of the ways to achieve this is by implementing the suitable, new technology to the production farm. Such action should minimize the quantity of inputs and improve the productivity, and ultimately augment profits. An expected impact of technological change on production function has been discussed below by taking an example of a year-round forage production system for a goat farm.

Impact of Technological Changes on Production Function

The concept of a year-round forage production (YRFP) approach in relation to technological change can be viewed as shown in Figure 14.4. There was no YRFP at the beginning. So, the production was only (0A) quantity with (f_0) input level. When the producer adopted a new technological approach of YRFP, the production curve shifted from PF₀ to PF₁ with a rise in output from 0A to 0B at the same level of given input f_0 . It means the YRFP helps open two possibilities as listed below.

- 1. More output (0B) can be produced with the same quantity of inputs (f_0) , or
- 2. The given level of output (0A) can be obtained with a reduced level of input usage (f_1), with all inputs/technology other than YRFP held fixed.



Figure 14.4. Technological change and the total product curve (input-output relationship). Source: Adapted from Colman and Young, 1989.

Farm Economic Concepts and Analysis

Economic analysis is a systematic approach for studying the allocation of resources to achieve the farm's objectives. Techniques of economic analysis help ensure efficient operations, minimize overhead costs, and compare costs and benefits. Some of the major types of economic analysis include gross margin analysis, break-even analysis, sensitivity analysis, cost-effectiveness, cost-benefit, and cost-minimization and/or profit maximization. Each of these analyses has been described below.

Gross Margin Analysis

Gross margin (GM) is the difference between the production costs and the revenue before accounting for certain other costs. Generally, it is calculated as the selling price of an item, less the cost of that item (production or acquisition costs). It takes into account majorly the variable costs and fixed costs directly linked to the production and sale, such as material costs and labor. It does not include indirect fixed costs, such as office expenses, rent, administrative costs, etc. GM is an indicator for determining whether a farm is profitable or not. Higher gross margins reflect greater efficiency in turning raw materials into income. To determine the gross margin, we apply the equation that follows. An example of gross margin and gross profit calculation is presented in Table 14.1.



We consider taxes, interest, depreciation, and administrative expenses while calculating the net margin and net profit. Gross margin and net margin are expressed as percentage terms in relation to revenue whereas gross profit and net profit are expressed in dollar value.

Table 14.1. Calculation of gross margin and gross profit (an example).

Income/Revenue	Unit	Quantity	Price/unit (\$)	Total amount (\$)
Does culled and sold	Number	20	50	1000
Manure sold	Sack	10	3	30
A. Total income/receipts				1030
Variable cost	Unit	Quantity	Price/unit (\$)	Total amount (\$)
Medicine & vaccine	\$	30	0.5	15
Drenching	\$	30	0.2	6
Marking & tagging	\$	0	0	29
Marketing expenses	\$	0	0	0
Supplementary feeding	\$	0	0	50
Нау	\$	0	0	200
Equipment fuel/rent	\$	0	0	50
Grain/Concentrate	\$	0	0	50
Predator control	\$	0	0	50
Other	\$	0	0	50
B. Total variable cost	\$			500
Gross margin	%			51.45
Gross profit	\$			530

Break-Even Analysis

Break-even analysis involves finding out the **break-even point (BEP)**, which is the point at which cost or expenses and revenue are equal; there is no net loss or gain, and one has "broken even" (Figure 14.5). It helps to provide a dynamic view of the relationships between sales, costs, and profits.



The break-even point is calculated by using fixed cost and contributing margin as presented below.



Break-even analysis is done for the following reasons:

- BEP is the intersection of the two functions: Revenue and Total cost.
- BEP tells us the amount of units we need to sell to break even.
- BEP is that volume of sales activity that would cover all the possible costs, but we do not make any money. So, the bottom line of the farm business should be to meet the BEP.

For example, let's assume, if a farm sells fewer than 50 goats each year, it will incur loss; if it sells more, it will make a profit. With this information, the owner/manager will then need to see if she/he expects to be able to raise and sell 50 goats per year. BEP analysis helps us to find the answers for the following questions:

• How many goats must I sell to cover all my costs?

- What would the break-even sales in dollars be?
- How many goats must I sell to obtain target profit of X dollars based on the available production data (selling price per goat, production cost per goat, fixed costs)?

If it is not possible to maintain the break-even point, the owner/manager should do the following to ensure viability of the farm:

- Try to reduce the fixed costs (by renegotiating rent, for example, or keeping better control of telephone and electricity bills or other costs).
- Try to reduce variable costs (the price it pays for hay and concentrates by finding a new supplier or by improving pastures, extending grazing period, and ultimately minimizing the requirements of purchased hay and concentrates).
- Increase the selling price of the goats.



Another concept related to break-even analysis is the **break-even price**, which is the amount of money for which a product must be sold for to cover the costs for producing it. In Figure 14.6, we can see that fixed cost (FC) remains the same irrespective of the revenue level; however, break-even points (A, B, C) (the points of intersection between the TC, total costs, and a TR (total revenue) (R1, R2, or R3) decrease as the revenue increase, given the different prices for the product.

Figure 14.6. Break-even analysis with various revenue lines. Source: Wikipedia (no date)

Economic Profit

An economic profit is the farm's total revenue minus its implicit and explicit costs. Explicit costs are actual cash payments for resources employed by a farm, such as wages, rent, interest, insurance, taxes, and so on. Implicit costs are opportunity costs of a farm using its own resources or those provided by its owners without a corresponding cash payment, e.g., company-owned building, time of the farm owner, and use of company funds. Economic profit takes into account the opportunity cost of all resources used in production. It is what a farm earns as an entrepreneur – an amount over and above what the farm's resources could earn in their best alternative use. As long as economic profit is positive, the producer is better off running his or her own farm than working for an institution. An example of calculating an economic profit is presented in Table 14.2.

Items	Unit	Total amount (\$)
Goat sales	\$	7000
Manure	\$	500
Other (grass seeds)	\$	100
Annual revenue (A)	\$	7600
Explicit cost	\$	
Material & equipment	\$	400
Labor hired	\$	200
Land rent	\$	500
Feeding, health cost	\$	1000
Total explicit cost (B)	\$	2100
Implicit cost	\$	
Owner's forgone wages	\$	5000
Forgone interest on savings	\$	250
Total implicit cost (C)	\$	5250
(D) Accounting profit (A - B)	\$	5500
(E) Economic profit (D -C)	\$	250

Table 14.2. Calculation of economic profit (an example).

Sensitivity Analysis

Sensitivity analysis is done to determine the income or loss of a farm at various levels of possible selling price, quantity sold, buying price for necessary inputs, scale or production, etc. In an enterprise with seasonal and cyclical price changes, sensitivity to variables such as concentrate, mineral supplements, hay, appropriate management practices, and identification of other key cost components is very important. Circumstances over which the producer has no control can cause havoc in raising small scale goat herd because of many uncertain variables/factors down the road, such as future tax rates, interest rates, inflation rates, headcount sales, selling price, ever increasing price of the grains/concentrate, and so on. We may not know these factors precisely or these factors are not known with great precision. So, sensitivity analysis becomes a key measure that tells the consequence if any of these uncertain variables deviate from our expectation: what will the effect be? Which variables are causing it? What will the change be (positive or negative) in the total output? Table 14.3 contains an example of sensitivity analysis (approximate imaginary data) considering two uncertain variables: one with increase in selling price of goats by 20 percent, and the other with the decrease in feed cost by 50 percent because of year-round forage production in the model, and their impact on the total farm income. Sensitivity analysis can be useful for a range of purposes as listed below:

• Testing the robustness of the results of a model in the presence of uncertainty.

- Increased understanding of the relationships between input and output variables in a model.
- Identifying model inputs that cause significant uncertainty in the output and should therefore be the focus of attention if the robustness is to be increased (perhaps by further consultation/knowledge/skill about the enterprise).

• Model simplification – fixing model inputs that have minimum or no effect on the output, or identifying and removing redundant parts of the model structure.

Table 14.3. Adjustment in the existing scenario: Impact of a 20% increase in the selling price of goats and a 50% decrease in the feed cost (hay) due to YRFP on the total gross and net margin remaining other variables constant.

			Existing	scenario	Projected scenario		
			Price/unit	Total		Price/unit	Total
Income/Revenue	Unit	Quantity	(\$)	amount (\$)	Quantity	(\$)	amount (\$)
Does	Number	0	0	0	0	0	0
Bucks	Number	0	0	0	0	0	0
Young kids	Number	20	50	1000	20	60	1200
A. Total income				1000			1200
Variable cost	Unit	Quantity	Price/unit (\$)	Total amount (\$)	Quantity	Price/unit (\$)	Total amount (\$)
Medicine & vaccine	Dollar	40	0.5	20	40	0.5	20
Drenching	Dollar	40	0.2	8	40	0.2	8
Marking & tagging	Dollar	0	0	29	0	0	29
Marketing expenses	Dollar	0	0	0	0	0	0
Supplementary feeding	Dollar	0	0	50	0	0	50
Нау	Dollar	0	0	200	0	0	100
Equipment fuel/rent	Dollar	0	0	50	0	0	50
Grain	Dollar	0	0	50	0	0	50
Predator control	Dollar	0	0	50	0	0	50
Other	Dollar	0	0	50	0	0	50
B. Total variable cost	Dollar			507			407
Gross margin	Percent			49.3			66.08
Gross profit (A-B)	Dollar			493			793
Fixed cost	Dollar	Rate	Loan amount (\$)	Total amount (\$)	Rate	Loan amount (\$)	Total amount (\$)
Interest	Percent	5%	5,000	250	5%	5000	250
Rent	Dollar			0			0
Тах	Dollar			20			20
Total fixed expenses (C)	Dollar			270			270
Net profit (A-B-C)	Dollar			223			523
Net margin	Percent			22.3			43.58

Impact of Year-Round Forage Production System on Goat Production

Before doing any impact analysis, it is important to visualize the situation of existing pastures with several months of forage scarcity period in the Southern US and the concept of developing year-round forage production system as presented in Figure 14.7 that depicts following three scenarios:

- 1. Availability of warm season forages exists for seven months in a year from April to October (in ideal condition).
- 2. Forage deficit period of five months or longer (November-March/April) is the most crucial time that requires the most purchased feed to sustain goat herds.
- 3. Year-round forage production (YRFP) system: The sole objective of this system is to reduce the forage deficit period (as mentioned in Number 2 above), thereby extending the grazing duration and lowering the feeding/production costs.



Figure 14.7. Existing situation with limited duration of forage production (), forage scarcity period (), and year-round forage production system ().

Before versus After Approach for Impact Assessment

Before versus after approach has compared the feeding cost incurred before and after year-round forage production system developed by selected goat producers. The basic concept of this approach has been presented in Figure 14.8, where 0B and 0A, respectively, are the feeding costs before and after developing year-round forage production system. The difference in the feeding cost is the direct impact of the year-round forage production system provided we isolate the influence of exogenous factors. The details of economic and ecological benefits associated with the year-round forage production system are presented in the following paragraphs.



Figure 14.8. Feeding costs of a goat farm before and after the development of year-round forage production system.

Source: Modified from Bauer, 2001.

Economic Benefit

The incremental income/margin from goat farming can be calculated to estimate the increased economic return and/or decrease in variable costs of production due to the introduction of yearround forage production system. The money paid for buying hay, concentrates, and other feedstuffs like peanut shell, corn, and commercial feeds when there is not much forage available for grazing can be saved after the development of year-round forage production (YRFP) system (Table 14.4 and 14.5). There were two cooperator goat producers, one from Selma and another from Phenix City, AL, who involved in developing the YRFP system and recording the variable costs for raising goats before and after YRFP system was developed. Recording began in October 2011 and ended in April 2012. There was not much forage available for grazing during October to December, 2011. However, because of the YRFP system developed in these farms starting fall 2011, there were plenty of different types of winter forages (grasses and legumes) available for grazing. Compared to the feeding costs of these farms before the YRFP, the costs of feeding after having established the YRFP system was considerably lower in Phenix City, AL (Table 14.4) and Selma, AL (Table 14.5).

In Phenix City, the record reveals that the average feed cost per month for feeding 35 goats was 300.00 (October-December feed cost total 1800/2 [because 50% of the purchased feed was saved for the rest of the season] = 900/3 = 300 per month) before the forage was established and the feed costs reduced to 63.00 (250/4 months) after the forages were established (Table 14.4). There was a huge saving of cost (300-63 = 237.00) per month after the YRFP system was developed. No feed was purchased from February to April because of abundant forages were available for grazing.

Months, Year		Purchased feeds	
Before YRFP, 2011	Hay (1)	Feed (2)	Total (3)
October	300	400	700
November	200	400	600
December	100	400	500
Sub-total	600	1200	1800*
After YRFP, 2012			
January	50	200	250
February	0	0	0
March	0	0	0
April	0	0	0
Sub-total	50	200	250

Table 14.4. Feeding costs before and after the development of year-round forage production (YRFP) system in Phenix City, Alabama, October 2011 to April 2012.

* 50 percent of the purchased feed was saved for the rest of the season.

In Selma (Table 14.5), the record reveals that the average feed cost for 40 goats per month was 301.00 (October-December feed cost total 1205*3/4 [because 25% of the purchased feed was saved for the rest of the season] = 904/3 = 301 per month) before the YRFP system was developed and the feed costs reduced to 80.00 per month after the YRFP system was developed. There was a huge saving in feeding cost (301-80 = 221.00) per month after the YRFP system was developed.

Table 14.5. Feeding costs before and after the development of year-round forage production (YRFP) system in Selma, Alabama, October 2011 to April 2012.

Months, Year		Purchased feeds	
Before YRFP, 2011	Hay (1)	Feeds (2)	Total (3)
October	60	320	380
November	325	400	725
December	0	100	100
Sub-total	385	820	1205*
After YRFP, 2011			
January	50	110	160
February	0	75	75
March	0	85	85
April	0	0	0
Sub-total	50	270	320

* 25 percent of the total purchased feed was saved for the rest of the season.

Ecological Benefits

We know chemicals are a major source of water pollution. Only about 10 percent of chemical pollution in the water comes from factories and other industrial sites; about two-thirds of water pollution mostly comes as run-off from agricultural pesticides and fertilizers (McEachern, 2009). However, when legume forages are established and managed in pastures, the possible pollution from commercial nitrogen fertilizer can be minimized or avoided completely. This is because legumes fix nitrogen (N), which is utilized by the legumes and associated grasses for their growth and development. The YRFP system discussed in previous paragraphs consisted of various legume forages, such as annual clovers (arrowleaf, berseem, crimson), hairy vetch, winter peas, and sericea lespedeza that fix N (Table 14.6). The economic value of the N fixed by these legumes depends on the market price of N fertilizer.

N fixed	lb/Acre/Year	N value (\$) @ 50 ¢/lb		
]	Range	R	ange	
50	150	25.00	75.00	
50	150	25.00	75.00	
50	150	25.00	75.00	
	<u>N fixed</u> 50 50 50	N fixed lb/Acre/Year Range 50 150 50 150 50 150	N fixed lb/Acre/Year N value (* Range R 50 150 25.00 50 150 25.00 50 150 25.00	

Table 14.6. Value and amount of nitrogen (N) fixed by various legumes.

Source: Ball and et al., 1996.

Based on the information presented in Table 14.6, the amount of nitrogen fixed by the leguminous forages and equivalent dollar amount based on the market price have been calculated in Table 14.7 for both locations. This implies that leguminous forages have dual advantages: reduce the negative externality of chemical fertilizers, and save equivalent dollar amount/reduce fertilizer cost, i.e., \$50/acre (d/a in Table 14.7) both in Phenix City and Selma.

Table 14.7. Value and amount of nitrogen fixed by the legumes in the producers' farms.

	Phenix City				Selma			
Leguminous forages	Area planted (Acre) (a)	Avg.* N fixed lb/Acre/yr (b)	Total N fixed/yr (c=a*b)	N value (\$) @ \$0.5 /lb (d=c*0.5)	Area planted (Acre) (a)	Avg. N fixed lb/Acre/yr (b)	Total N fixed/yr (c=a*b)	N value (\$) @ \$0.5/lb (d=c*0.5)
Annual clovers, hairy vetch, winter peas, and sericea lespedeza	4.25	100.00	425.00	212.50	8.47	100.00	847.00	423.50

* Avg. = Average, N = Nitrogen.

Besides the economic and ecological benefits calculated in monetary values, goat producers have expressed that they realized less parasitic problems and better performance of animals, and reduced labor requirements for managing their herds after the development of year-round forage production system. However, further analysis has to be done to verify these statements.

Tools of Farm Management Analysis

Farm Planning and Budgeting

The planning of the farm operations and their execution is the secret of their economic success. With the recent technological developments in agriculture and livestock production, farming has become more complex business and requires careful planning for successful operations. The ultimate objective of farm planning is the improvement in the standard of living of the farmer and immediate goal is to maximize the net incomes of the farmer through improved resource use planning. According to Johl and Kapur (1987), farm planning process introduces a measure of economic content into farming business. Those who cannot make rational decisions and need adjustments will find the farming not a profitable proposition for them.

There are several ways of preparing a detailed farm plan and budget. One can start with a feasibility study and financial analysis. If an entrepreneur is determined to manage resources and has a clear vision of adopting goat farming as a full-time occupation, one can prepare a long-term plan or start with a small scale operation with a short-term plan and build a long-term plan as she/he continues the operation. Regardless of the scale of operation, a producer or farm manager must know about the farm budgeting and apply it to run the business successfully.

Farm Budgeting

Farm budgeting is a process of estimating costs, returns, and net profit of a farm or a particular enterprise. Budgets help ensure that investors make decisions based on realistic data, not just emotions and imagination, and evaluate alternative plans and select the one that is most suitable. Knowledge of budgeting and the ability to use budgets will help make the right decision. There are three basic types of budgets (Whole-farm, Enterprise, and Partial) that can be used in the farm business management process. Each type of budget provides different information to the manager for use in the decision-making process. The common thread in each type is that, if properly defined and used, the budget format permits the manager to use economic logic to answer questions of what, how much, and when resources should be used to achieve the goals and objectives as established by the farm family.

Enterprise Budget

The enterprise budget becomes much more important when we talk specifically about an enterprise such as goat, cattle, and poultry production. An enterprise budget is a planning tool that provides estimates of revenue, costs, and profit of an enterprise for a given period. It should include a production goal, the production techniques to be employed, the land resource required, and the capital and labor requirements. An enterprise budget estimates the full economic costs and returns projected to accrue to an activity - raising goats or producing grain - for some period, generally one year. It also incorporates information about the specific resources, management practices, and technology used in the production process. An enterprise budget is a statement of:

- Expected revenue and expenses incurred,
- Profitability, not just cash flow, break-even values, and the potential return on an investment, and
- Anticipated costs of operating inputs plus fixed costs (interest, depreciation, taxes, and insurance) on machinery, equipment, and goats along with expected production per doe.

An example of an enterprise budget for a goat operation has been presented in Table 14.8 with the following assumptions.

<u>Assumptions:</u> Average price of meat goat sale per head = \$100.00 Average price of culled doe per head = \$80.00 Average price of culled buck = \$90.00 Average price of culled kid per head = \$60.00 Manure sold = \$30.00 Clips/goat hair sold = \$10.00

Does: 30, Bucks: 2 Kidding rate: twin Mortality rate: 5% Acres in forage: 5

The figures (costs and revenues) in this budget are the best estimation as production costs vary from one producer to another depending on locations, assumptions, and associated production factors. Therefore, this budget is a guideline to help producers and readers to have a picture of the budget in mind. Data necessary for preparing an enterprise budget are physical inputs and outputs, and prices for those inputs and outputs.

Partial Budgeting

Partial budgeting refers to estimating the outcome or returns for a part of the business, i.e., one or a few activities within a given business or enterprise. Partial budgets are commonly used to estimate the effects or outcomes of possible adjustments in the farm business before such adjustments are actually made. It provides a method for deciding how far expenses and yields should be increased in a particular enterprise. Partial budget helps producers to evaluate the economic effect of minor adjustments in some portion of the business, for instance, development of Year Round Forage Production (YRFP) system, while remaining aspects of the business are kept fixed in the short run. Partial budget basically can evaluate changes in resource uses that are not fixed. Many changes that do not require a complete reorganization are very common on a farm. Given a fixed set of resources, the producer can employ these resources in more than one way in response to changes in product price, carrying capacity of the pasture, and feed cost. According to Dalsted and Gutierrez (2012), partial budgeting is based on the principle that a small change in the organization of a farm business will have one or more of the following effects:

- Eliminate or reduce some costs.
- Eliminate or reduce some returns.
- Cause additional costs to be incurred.
- Cause additional returns to be received.

Production/Receipts	Unit	Price /unit (\$)	Quantity	Total amount (\$)
Kids culled	Head	60	5	300
Does culled	Head	80	2	160
Bucks culled	Head	90	1	90
Meat goat sale (direct market)	Head	100	15	1500
Manure	Sack	3	10	30
Clips/goat hair	Dollar			10
Total Projected Receipts (A)	Dollar			2090
Variable Cost/Operating cost	Units	Price /unit (\$)	Quantity	Total amount (\$)
Feed				
Pasture (seed, fertilizer, lime)	Acre	50	5	250
Нау	Ton	75	6	450
Concentrate	CWT	11	15	165
Creep feed for kids	CWT	12	0.5	6
Salt/Minerals supplement	Head	1.5	32	48
Veterinary/Animal health				
Deworming (3X)	Head	5	11	55
Vaccination (2X)	Dose	0.5	64	32
Antibiotics	Year	25	1	25
Facilities and equipment	Head	1	32	32
Marketing	Year			25
Miscellaneous	Head	1	32	32
Total Variable Costs/Operating cost (B)	Dollars			1120
			Loan	Total
Fixed Cost	Unit	Quantity/Rate	amount (\$)	Amount (\$)
Interest on capital investment	Description	_	2000	450
(procuring does and bucks, making sned)	Percent	5	3000	150
Expense on shed (depreciation, repair)	Dollars			200
Total Fixed Costs (C)	Dollars			350
Total Costs (B + C)	Dollars			1470
Returns above total variable cost (Gross				
profit) (D = A-B)	Dollars			970.00
Returns above all specified costs (Net profit) (E = D – C)	Dollars			620.00

Table 14.8. Enterprise budget for raising meat goats (an example).

CWT = a hundredweight is equal to 100 pounds.

Partial budget example

Herd size: 35 Does and 2 Bucks, Area under YRFP: 8.47 Acres, Location: Selma, Grazing period: 4 months (Jan-Apr, 2012)

Partial budget calculation example has been presented in Table 14.9.

S.			Amount				Amount	
No	Items	Unit	(\$) Debit	S. No	Items	Unit	(\$) Credit	
1	Interest @ 5% on			1	Cost reduction/saving			
	loan (\$3,000.00) to							
	procure production							
	inputs (seeds,							
	fertilizer, etc.)	Dollar	150			Dollar		
2	Machinery (tractor)							
	on rent for land							
	preparation and				Medication (less parasites			
	plantation	Dollar	200	1.1	infestation)	Dollar	30	
3	Decrease in return							
	(opportunity cost of				Concentrates and hay			
	land use)	Dollar	0	1.2	/month	Dollar	884	
4	Hired labor (2 days				Labor man-days			
	@64)	Dollar	128	1.3	(@1hr/d*120d*\$8/hr)	Dollar	960	
				2	reduced fertilizer cost			
					(\$50/Acre*8.47 Acres)	Dollar	424	
Α	Total increased costs			В	Total reduced costs and			
	and reduced returns	Dollar	478		increased returns (\$)	Dollar	2298	
Difference in income (gain) = B-A = 1820								

Table 14.9. Partial budgeting of a goat farm for developing the year-round forage production system (Example).

As shown in table 14.9, introduction of the YRFP has reduced the feed cost by \$221.00/month (four months' data of the farm). Simultaneously, it has helped reduce the parasite infestation thereby reducing the medication costs (by \$30.00-four months' data of the farm). Also, the YRFP has reduced the cost of nitrogen fertilizer (\$50.00/acre) as a result of nitrogen fixation by the leguminous forages. It also has reduced the labor man-days required to take care of the goats at least by one hour a day (four months' data of the farm) and calculated in monetary value (\$8.00/hour). Inputs required for developing year-round forage production and grazing management were provided by the Southern Sustainable Agriculture Research and Education (SARE) program and Tuskegee University Cooperative Extension Program, and have been calculated as a lump sum of three thousand dollars and charged interest of five percent considering as a loan amount.

Economies of Scale and Production Cost

Economies of scale are the cost advantages that a farm enterprise obtains due to size, with cost per unit of output generally decreasing with increasing scale of production as fixed costs are spread out over more units of output. Often operational efficiency is also greater with increasing scale of production, leading to lower variable cost as well. This refers to the reduction of per-unit costs through an increase in production volume. The simple meaning of economies of scale is doing things more efficiently with increasing size of operation. Economies of scale often originate with fixed capital, which is lowered per unit of production as the size of an operation increases (Fig. 14.9). This means that as a farm grows with increasing goat herd size, the farm will have a better chance of decreasing its costs. An economic growth may be achieved when economies of scale are realized.



Figure 14.9. Economies of scale and production cost. LRAC = long run average cost

In Figure 14.9, as quantity of production increases from Q to Q2, the average cost of each unit decreases from C to C1.

Hands-on Activities

The following calculations and exercises will be done during the hands-on session:

- 1. Feeding costs before and after the development of year-round forage production system Phenix City and Selma, Alabama,
- 2. Gross margin and gross profit,
- 3. Farm's accounting and economic profit,
- 4. Sensitivity analysis,
- 5. Profit maximization,
- 6. Economic and ecological impact of the year-round forage production system,
- 7. Total, variable, marginal, and opportunity costs, and
- 8. Enterprise and partial budgeting.

Key Points

- 1. Knowledge of basic farm/production economics is necessary to run a farm profitably.
- 2. Well-managed year-round forage production system has higher economic and environmental benefits than the traditional/existing system.
- 3. Break-even analysis of an enterprise is essential to understand the unit of production for break-even, break-even-sales, and loss and profit of that enterprise.
- 4. A strategic production plan followed by enterprise budgeting is helpful to overcome a forage deficit situation and thus increases the farm's profit margin.
- 5. Recording inputs and outputs is the major pre-requisite to perform economic analysis.
- 6. Gross margin and break-even analyses are two major keys to measure the economic trend of a farm.

- 7. Golden rules of profit maximization are the fundamental concepts of production/farm economics.
- 8. Sensitivity analysis is the key to know the impact of uncertain variables and/or factors on the total output.
- 9. Opportunity cost is a key concept to identify what commodity to produce and how much to produce.

References

- Ball, D. M., D. S. Hoveland, G. D. Lacefield. 1996. Southern Forages. 2nd ed. Potash and Phosphate Institute and the Foundation of Agronomic Research, Norcross, GA.
- Bauer, S. 2001. Konzeptstudie: Evaluierung Zunkunftsinitiative Rheinland-Pflaz. Professur fuer Projekt-und Regional Planung. Universitaet Giessen, Deutschland.
- Colman, D. and T. Young. 1989. Principles of Agricultural Economics. Markets and prices in less developed countries. Cambridge University Press, Cambridge.
- Dalsted, N. L. and P.H. Gutierrez. 2012. Partial Budgeting. eXtension no. 3.760 Colorado State University Cooperative Extension. Accessed Jan. 11, 2013. http://www.extension.org/pages/11809/partial-budgeting.
- Johl, S. S. and T. R. Kapur. 1987. Fundamentals of Farm Business Management. Kalyani Publishers, Ludhiana.
- Luginbuhl, J. M. 2006. Pastures for Meat Goats. In: Meat Goat Production Handbook, ed. T.A. Gipson, R.C. Merkel, K. Williams, and T. Sahlu, Langston University, ISBN 1-880667-04-5. Accessed Jan. 11, 2013. http://www.extension.org/pages/19396/goat-pastures-andforages.
- McEachern, A. W. 2009. Economics: A Contemporary Introduction. 9th ed. South-Western Cengage Learning, Mason, OH.
- Wikipedia. Cost and Break-Even Analysis. Accessed Dec. 22, 2012. http://en.wikipedia.org/wiki/Break_even_analysis.

APPENDICES

Appendix 1. Common browse species adapted to the Southeast Region.



Blackberry (Rubus spp.)



Smooth Sumac (*Rhus glabra*) Source: http://www.ag.ndsu.edu/trees/ handbook/th-3-57.pdf



Poison Ivy (*Toxicodendron radicans*) Source: http://upload.wikimedia.org/wikipedia/commons /b/bf/Poison_Ivy_Leaves.jpg



Eastern red cedar (*Juniperus virginiana*) Source: http://www.treetopics.com/juniperus_vir giniana/gallery1.htm



Winged elm (Ulmus alata)



Greenbrier (Smilax spp.)



Trumpet creeper (*Campsis radicans*)

Hawthorn (Crataegus viridis)



McCartney rose (*Rosa* spp.)



Japanese honeysuckle (Lonicera japonica)



Wild plum (*Prunus americana*)



American beautyberry (*Callicarpa americana*)



Sweet gum (*Liquidambar stryraciflua*) Source:

http://www.clemson.edu/extension/natural _resources/tree_finder/by_name/sweetgu



Goundsel tree (Baccharis haliminifolia)



Mulberry (Morus spp.)



Honey locust (Gleditisia triacanthos)



Pepper vine (Ampelopsis arborea)



Chinese privet (*Ligustrum sinense*)



Multiflora rose (*Rosa multiflora*) Source: http://extension.entm.purdue.edu/CAPS/pestInf o/pics/big/multifloraRose1.jpg



Black locust (*Robinia pseudoacacia*) Source:

http://www.clemson.edu/extension/natural_reso urces/tree_finder/by_name/black_locust_robinia _pseudoacacia.html



Kudzu (*Pueraria lobata*): Left – leaves, flower, and pods; right: kudzu taking over the trees and ground vegetation

Note: Photos by Uma Karki where source is not indicated.

Appendix 2. Modified McMaster Egg Counting for Quantification of Nematode Eggs (Miller et al., 2012).

Fecal worm egg examinations or flotations are based on density or weight of the eggs in different chemical solutions.

Materials:

Compound microscope Scale (to weigh in grams) Saturated sodium chloride (table salt solution); see recipe below 50mL centrifuge tube with screw cap (tube should be marked in 1mL increments) Tongue depressor Pipette (a 1mL syringe or eye dropper works well) McMaster egg-counting slide Paper towels Fresh fecal sample (keep refrigerated until tested) Table salt, 1 pound box Tap water, 3 quarts

Preparation of Saturated Salt Solution:

Heat 1 lb of table salt in 3 quarts of tap water in pan while stirring until boiling; then let cool to room temperature. The solution will look cloudy, and some material will precipitate (this is to be expected). Pour the clear part of the solution into a dispensing container and store at room temperature. Do not refrigerate.

Collection of Fecal Sample

- 1. Collect fresh feces that are not contaminated by dirt or bedding. This may be accomplished by using a rubber glove to extract feces directly from the rectum, or pick feces from the ground soon after deposition.
- 2. Label container with the name or number of the animal and the date. Fresh samples work best, but accurate results can be obtained if the samples are refrigerated. If samples are not refrigerated, the eggs will hatch within 12-24 hours. Once hatched, they cannot be counted.

McMaster Egg Counting Procedure:

- 1. Weigh out 2g of feces into a 50mL centrifuge tube and fill to 30mL with the salt solution. It is recommended to purchase a small scale for accurate weighing of feces, but if a scale is not available, a close estimation can be made by placing 28mL of salt solution into a 50mL centrifuge tube and then adding feces until a volume of 30mL is achieved.
- 2. Pour off approximately 25mL of the salt solution into another small container, keeping feces in the tube (a tongue depressor can be used for this purpose).
- 3. Let soak for a few minutes and mix (soft feces) or break up (fecal pellets) with a tongue depressor.

- 4. Add back approximately half of the salt solution and mix well, breaking up any remaining feces as well as possible.
- 5. Add back the remaining salt solution and screw the cap back onto the tube.
- 6. Shake tube vigorously for approximately 1 minute to homogenize any remaining feces as much as possible.
- 7. Set tube aside for a few minutes to let bubbles dissipate.
- 8. Wet McMaster chamber with water, and dry top and bottom on paper towels.
- 9. Rock (do not shake) tube side to side several times to thoroughly mix solution without causing large air bubbles to form.
- 10. Using 1mL syringe or eye dropper, immediately take up a sample of the suspension and fill both sides of counting chamber. Work quickly. If it takes more than a few seconds to load the first chamber, then mix fecal solution again and refill pipette before loading the second chamber.
- 11. Let stand for 1 to 2 minutes to allow eggs to float to top.
- 12. Count all eggs inside of the two grid areas viewed under low power (using a 10X objective). Focus on the top layer, which contains the very small air bubbles (seen as small black circles; if numerous large air bubbles are visible, remove the fluid and refill).
- 13. Count only trichostrongyle or strongyle eggs (oval, approximately 80 to 90um long). Do not count *Strongyloides* (oval, approximately 50um long), tapeworm eggs (triangular or D-shaped), coccidian (various sizes). Notation is made regarding the presence of other species of eggs, but only trichostrongyle or strongyle eggs are counted.
- 14. Once filled, the chambers can sit for no longer than 60 minutes before counting without causing problems. If the samples are permitted to sit for any longer, drying or crystal formation may begin.
- 15. Multiply the total egg count (from both chambers) by 50 to determine eggs per gram of feces (EPG).

*Because this is a dilution technique, it will not detect less than 50 eggs/g of feces. Clean the chamber with water soon after completing the chambers. It is important to use the same procedure each time.
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