Part 645 – National Range and Pasture Handbook

Subpart H – Livestock Nutrition, Husbandry, and Behavior

645.0801 General

A. Successful conservation and efficient use of grazing lands depend on correlation of the treatments and management of forage plants with the management of the animals that harvest the plants. NRCS conservationists who work with livestock producers must be thoroughly familiar with locally adapted and customary livestock husbandry and livestock management principles and practices applicable to advise customers on proper and efficient use of grazing resources. NRCS will not provide technical advice or assistance to livestock producers on matters relating primarily to animal breeding, genetics, animal health problems (except when animal health is related to forage resources) or make nutritional recommendations such as feed rations. However, conservationists should acquire enough information about these matters so that they can communicate effectively during the planning process and to adequately discuss livestock health, nutrition, and behavior with livestock producers.

B. The 2018 Farm Bill states "livestock means all animals raised on farms, as determined by the Secretary" [16 USC 3801 (a) (17)]. For purposes of this document livestock will be separated into ruminants and non-ruminants. The ruminant section will include cattle (further separated into beef and dairy), sheep, and goats; non-ruminant section will include horses, swine, and poultry. It is important to understand non-ruminant fermenters (i.e., swine, poultry) will obtain most of their nutrition from feedstuffs supplied. Swine and poultry can obtain approximately 5–20 percent of their nutritional needs from forages, the balance must be obtained from grain or other feedstuffs (i.e., vegetable or bakery waste, or brewery grains). Refer to feed management technical notes for specific animal nutritional needs.

C. Genetic factors, age of animal, sex of animal, body composition of animal, physical activity, and lactation (where appropriate) are also discussed in this subpart for animals.

645.0802 Nutrition

A. One of the greatest challenges associated with successful livestock management combined with integrating grazing management and forage production is animal nutrition. Understanding the complex issues of animal nutritional demand, forage nutritional values, and grazing management influence on forage nutritional values and production is the key to successful planning and management on grazing lands.

B. Developing a good feeding and management program is important for managers to meet livestock goals and herd performance objectives. Many factors affect the requirements of animals and the extent of nutrient utilization. The effect of genotype, physiological state, and environment on voluntary feed consumption is mediated by the animals' metabolism, and consumption is generally dependent upon forage quality.

C. When animals graze, the energy contained in those plants is used for maintaining body functions (respiration, blood flow, and nervous system functions), for gain of tissue in growing animals, and for products (milk, wool).

D. The synthesis of protein in the animal's body, which forms muscle, organs, soft body tissue, and animal products, should be the main objective of animal nutrition. Different kinds of animals and various breeds have different nutritional requirements during the year and acquire different values from forages and supplements. See exhibit 1 for kinds of animals (beef and dairy cattle, sheep, goats, and horses) and representative breed types.

(1) Ruminants
   (i) Basic nutritional requirements include energy (i.e., carbohydrates), protein, minerals, vitamins, and water. Energy is responsible for maintenance and growth functions and the generation of heat. Protein grows tissue and performs other vital functions. Vitamins such as A and E, calcium, phosphorus, and selenium may be fed free choice as a mineral supplement (Rinehart, ATTRA 2008).
   (ii) Different types of animals and various breeds have different nutritional requirements during the year and acquire different values from forages and supplements.
(2) Non-ruminants
   (i) Basic nutritional requirements like ruminants include–energy, protein, minerals, vitamins, and water. However, non-ruminant animals are not able to obtain all their nutritional needs from forages alone. Providing concentrates to their diet is very important to ensure maintenance and growth.
   (ii) Pastured swine and poultry will need supplementation other than forage, since they are nonruminants
      - Refer to the State and federal regulation on food waste if being fed to pastured swine.
      - The particle size of grain fed to pastured swine and poultry is important since particle size affects breakdown and utilization.

E. The bulk of dry matter in plants is made up of three groups of organic compounds:

(1) Proteins
(2) Carbohydrates
(3) Fats

F. Carbohydrates, proteins, and fats are the fuels that animal cells are capable of converting into various forms of energy. This energy is used for mechanical work of muscles, synthesis of macromolecules from simpler molecules, and for providing heat. Heat energy is referred to as a calorie (cal). Inorganic matter includes salts minerals, and trace elements.

645.0803 Maintenance, Growth, and Production

A. Maintenance requirement for energy is the amount of feed energy intake that will result in no net loss or gain of energy from the tissues of the animal body (7th NRC Beef). Maintenance is comprised of the following processes or functions: body temperature regulation, essential metabolic processes, and physical activity. The selection of animals for lean tissue growth has resulted in some extreme conditions that present interesting models of animal growth and also demonstrate how genetic selection can be used to direct the partitioning of nutrients for tissue growth (Mitchell, 2007). Partition of nutrients for pigs and sheep were prioritized first for brain and CNS (central nervous system), then by bone, muscle, and fat (Hammond, 1944; Mitchell, 2007). Factors affecting maintenance and voluntary intake include genetic factors, age of animal, sex of animal, body composition of animal, physiological, and environmental factors.

B. **Large Ruminants: Beef Cattle**

(1) Genetic factors
   (i) Genetic variations in ruminants can influence feed consumption. Animals with higher potential for feed consumption exhibit enhanced tissue metabolism as indicated by a higher basal metabolism and maintenance requirement. Under optimal conditions and

environment, feed intake should be affected by the animal's genetic potential to use energy. For example, the Brahman breeds have a lower basal net energy requirement than European breeds, and a dairy cow has more soft tissue to maintain than a beef breed, making its basal net energy requirements higher.

(ii) Voluntary feed intake is affected by genotype interactions with type of diet and various components of the environment. Rapidly growing, slowly maturing livestock (Hereford, and Angus) are more efficient producers of protein than are slower growing, early maturing animals (Simmental and Charolais).

(2) Age of the animal

Age has a pronounced effect on basal metabolism. As the animal gets older, the basal metabolism goes down. The portion of energy derived from the oxidation of protein instead of fat decreases with age. Younger animals require more protein and energy to maintain condition and growth, so basal metabolism is high.

(3) Sex of the animal

The expenditure of energy is different between sexes. The basal metabolism rate is higher for males than it is for nonpregnant females of the same age and size. In domestic animals, castration results in a 5 to 10 percent depression in basal metabolism. Indications are that sex hormones can increase the metabolism and nutritional requirements of both sexes.

(4) Body condition of the animal

(i) Body condition scoring (BCS) allows producers of livestock to evaluate animals with a scoring system that reflects reproductive performance. For cattle, it is best used at calving time to assign a score. This percentage of body fat in livestock at different stages of the production cycle is important in determining their reproductive performance and overall productivity. Goals should be set for BCS scores at the time of breeding because it can affect conception rates. BCS should not be used for steers or feeder cattle, muscle scoring will be used for those animals.

(ii) Several factors affect body condition scores:

- Climatic conditions
- Stage of production
- Age
- Genetics
- Birthing date
- Weaning date
- Forage management

(iii) The amount and kind of supplemental feeding required to meet performance are influenced by the initial body reserves of protein and fat which also influences overall body condition score. Body condition scoring or the right condition rating is a guide for evaluation of the nutritional status of the animal. This rating is a more reliable guide than live weight or shifts in body weight. Live weight can be mistakenly used as an indication of body condition and fat reserves because the fill of the gut and the products of pregnancy prevent weight from being an accurate indicator of condition.

(iv) BCS are numbers to suggest the relative fatness or body composition of the animal. It can be a simple indicator of available fat reserves which can be used by the animal in periods of high energy demand, stress, or suboptimal nutrition scores range from 1 to 9 for beef cattle.

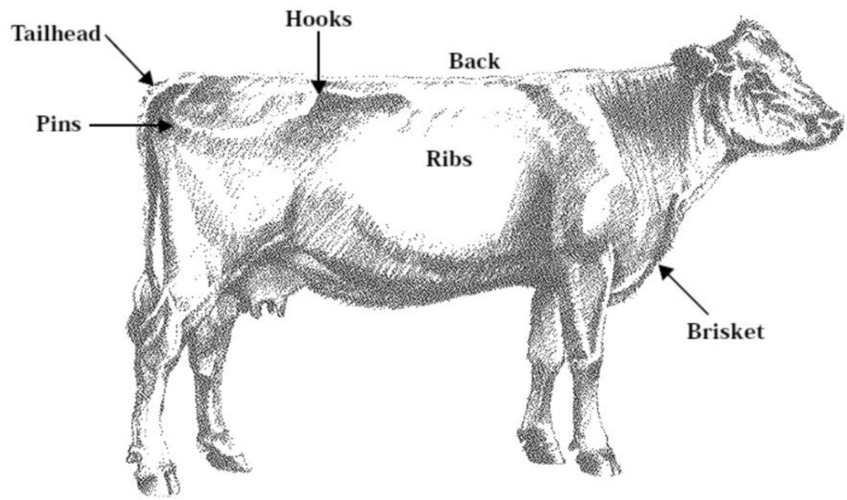
(v) Cattle: A body condition score of 5 or more (at least 14 percent body fat) at calving and through breeding is recommended for good reproductive performance for beef cows. A body condition score of 5.5 is recommended for first calf heifers to compensate for the additional nutrient requirements plus growth.

BCS and pregnancy rate. Cows that are thin following calving have a longer period between calving and re-breeding, as compared to a cow that is adequately conditioned. The impact on pregnancy rate of a thin body condition at calving is negative unless enough time is allowed to recover body tissues.

(vi) Description of body condition scores

Cattle: The different BCS ratings are described in table H-1. Figure H-1 shows the reference points for body condition scorings.

Figure H-1. Reference points for body condition score for cattle



Reference points for body condition score

Table H-1. Description of body condition scores for cattle

Body score	Description of cow condition
1	Severely emaciated. Bone structure of shoulder, ribs, hooks and pins is sharp to the touch and easily visible. Little evidence fat deposits or muscling
2	Emaciated. Little evidence of fat deposition but some muscling in the hind- quarters. The backbone feels sharp to the touch.
3	Very thin, no fat on the ribs or brisket, and some muscle still visible. Back- bone easily visible.
4	Thin, with ribs visible but shoulders and hindquarters still showing fair muscling. Backbone visible.
5	Moderate to thin. Last two or three ribs cannot be seen unless animal has been shrunk. Little evidence of fat in brisket, over ribs or around the tailhead.
6	Good smooth appearance throughout. Some fat deposits in brisket and over the tailhead. Ribs covered and back appears rounded.
7	Very good flesh, brisket full. Fat cover is thick and spongy, and patchiness is likely. Ribs very smooth.
8	Obese, back very square, brisket distended, heavy fat pockets around tailhead. Square appearance.
9	Rarely observed. Very obese. Animal's mobility may be impaired by excessive fat.

(5) Physiological state

(i) Pregnancy–Nutrient needs for reproduction generally are less critical than during rapid growth but are more critical than for maintenance alone. If nutrient deficiencies occur prior to breeding, animals may be sterile, have low fertility, silent estrus, or fail to establish and maintain pregnancy. Underfeeding during growth causes delayed maturity and underfeeding and overfeeding of protein cause reduced fertility. Energy needs for most species during pregnancy are most critical during the last third of the term. Pregnant animals have a greater appetite and spend more time grazing and searching for food than the nonpregnant animal. Nutritional deficiencies in the pregnant animal, especially protein deficiencies, first affect the weight of the female and not the newborn. However, health and vigor of the calf may be affected.

(ii) Physical activity– Maintenance requirements of livestock are increased by activity. As a general guideline, the maintenance of an animal is increased by about 0.9 Mcal/day for cows in grazing situations compared to those in a dry feedlot. Cows that are required to graze over wide areas or on steep slopes require additional energy, so adjustments are necessary to maintain energy requirements. The cost is also higher for larger animals than for smaller animals. Animals walking on a horizontal surface expend about 1.7 to 2.5 joules of energy per meter per kilogram of body weight. Animals walking with a vertical change (increased slopes) expend 12 to 20 times more energy than those on slopes of less than 15 percent. Work activities result in an increased energy demand for the portion of work done and the efficiency with which it is accomplished. Carbohydrates are more efficient sources of energy for work than fats.

(iii) Lactation–Lactation results in more nutritional stress in mature animals than in any other production period except heavy, continuous muscular activity. During the year, high production cows and goats produce milk with a dry matter content equivalent to 4 to 5 times that of the animal’s body and can reach as high as 7 times body dry matter. High producing cows can give so much milk that they cannot consume enough feed to prevent weight loss (attributed to mobilization of fat stores/reserves during periods of lactation. Milk is 80 to 88 percent water, so water is a critical nutrient to maintain lactation. All nutrient needs are increased during lactation. In cow’s peak lactation occurs in mature animals from 30 to 45 days after parturition and then gradually tapers off. Therefore, the peak demands for nutrients follow the typical milk flow characteristics for the species concerned. Limiting the water or energy intake of the lactating animal results in a marked drop in milk production, whereas protein limitation has a less noticeable effect. Peak milk production in 2-year-old cows occurs at about 30 days and lasts for shorter periods. Deficiencies of minerals do not affect milk composition but result in rapid depletion of the lactating animal’s reserves. The effects of nutrient deficiencies during lactation often carry over into the next pregnancy and the next lactation.

(6) Environmental factors

(i) The climatic conditions browsing, and grazing animals are exposed to can significantly affect the animal’s intake. Some domestic animals’ body temperature exceeds that of the environment. This relationship results in heat flow from the animal to the environment. Within a range of ambient temperatures, the heat produced by normal metabolism of a resting animal is minimal and is enough to cover this heat loss.

(ii) Animals lose heat by conduction, convection, and radiation from the body surface and evaporation of water from the body surface, lungs, and oral surfaces. The rate heat is lost from the body is determined by the difference between body surface temperature and the surrounding environmental temperature. The body temperature is greatly influenced by the insulation of subcutaneous fat, skin thickness, and skin covering or hair length. Insulation benefits are also greatly reduced by air movement or when the body surface is wet. Most animals have a much better means of protecting themselves from the cold than in a hot climate.

(iii) Thermoneutral zone–When the animal is in the thermoneutral zone (TNZ) no physiological processes are activated that require the expenditure of a considerable amount of energy to maintain normal body temperature. In the TNZ, body temperature is physiologically regulated by the constriction or dilation of the peripheral blood vessels and by some sweating. Little energy is required by these processes, and intake is not affected when temperatures are in the animal's TNZ. When the ambient temperature is below the lower critical point of the TNZ, body temperature is regulated by shivering. Table H-2 shows typical TNZ's for different species.

Table H-2. Typical thermoneutral zones

Species	Temperature (ºF)
Cattle	41– 68
Calves	50– 68
Sheep	70– 88
Goats	50– 68

(iv) Low temperatures–Temperatures below the thermoneutral zone may have stimulated or depressed intake rates, depending upon precipitation. Rain, snow, and muddy conditions depress intake because of decreased grazing time. Dry, cold conditions can generally stimulate intake.

Nighttime cooling allows animals to shift their grazing times to night, which can reduce grazing time lost during the day.

(v) High temperatures–In a hot climate the animal must cool itself by increasing evaporation from the body surface, by more rapid respiration and panting, finding shade, or by immersing itself in water. The actual temperature that may cause heat stress is reduced by high humidity (which reduces evaporative cooling rate), a high level of feeding, feeding any ration that produces a high protein or high fiber for ruminants, or restriction of water consumption. Evaporation is the only way an animal can cool itself (other than immersion in cool water) if the environmental temperature exceeds body temperature.

Voluntary consumption of feed has been reported to decrease by 50 percent in the first 8 days after exposure to heat loads and decreases to only 10 percent reduction after 17 to 24 days as the animal adjusts to the high temperatures. Above the upper critical point, animals pant and increase their rate of respiration in addition to sweating. Animals that do not tolerate heat can have intake reduced as much as 35 percent at temperatures of 95°and no nighttime cooling. At the same temperature with nighttime cooling, intake is reduced only 20 percent.

(7) Forage quality and quantity

(i) Forage intake is affected by several factors:

- Body weight
- Forage quality
- Forage quantity
- Stage of production
- Supplemental feeding strategy
- Genetics
- Environmental conditions

(ii) Quality–Intake is most influenced by the quality of forage. As the quality declines, intake is drastically reduced. Different species and animals digest nutrients with different efficiencies. The greatest differences are between monogastric species and ruminants. The greatest variations occur in the digestion of roughages. Sheep have a higher digestion coefficient than cattle of feeds with digestibility greater than 66 percent digestible organic matter (DOM). Below 66 percent, cattle tend to have a higher digestibility than sheep, which indicates a higher capacity to digest fiber. Crude fiber tends to depress digestibility. The stage of maturity of forage plants also influences their digestibility: As the plant matures, the cell wall content increases, the soluble cell content decreases, and the plant becomes less digestible.

(iii) Although native forage quality generally deteriorates as the growing season progresses, recent research suggests that farmers and ranchers can compensate for poor forage quality by planting introduced forages and integrating year-long livestock grazing practices (such as bale and winter grazing). Adoption of alternative practices could also offset the adverse environmental impacts of a period of confined feeding of grains by reducing greenhouse gases associated with fertilizer and fuel use, and potentially curtailing run off water pollution. Such as a switch to pastured or range fed beef could offer alternative cattle production systems that may generate environmental and economic benefits: https://www.ucsusa.org/sites/default/files/attach/2017/11/reintegrating-land-and-livestock-ucs-2017.pdf

C. **Large Ruminants: Dairy Cattle**

(1) Genetic Factors

(i) Milk production is expressed phenotypically and may or may not be transferred to the offspring, this is the challenge for a dairy breeder to determine which cows and bulls to breed in order for the genetic trait to be transferred to offspring (Kiplagat et. al., 2012). Crossbreeding has been common in the United States by crossing a Jersey sire with a Holstein heifer or cow due to the ease of a Jersey's high calving ease (Armstrong and Heins, 2020). Crossbred animals tend to have increased fertility, longevity, and health, known as hybrid vigor. Pasture based producers typically have Jersey breeds due to their ability to withstand heat stress in reproductive performance (Probert, 2012).

(ii) The most popular breed in the United States is the Holstein breed. They are known for their high productivity and large body frame; due to this it takes them longer to replenish body condition and return to estrus after calving compared to other breeds and even crosses such as the Holstein/Friesian breeds. Those characteristics can present a challenge for seasonal operations where they must calve on a 12-month interval (Probert, 2012).

(2) Age of Animal

Growing heifers require similar dry matter intake as beef heifers; DMI will change during late gestational period (NRC, 2001). It is important to ensure heifers receive adequate nutrition to be fertile and cycling by 13-15 months old and continued growth occurs, so they are large enough at calving time (Dinsmore, 2021).

(3) Sex of Animal

Regulation of nutrient partitioning to support fetal development and subsequent milk synthesis is complex. From studies with dairy cattle, described how homeorhesis comes into play during pregnancy and lactation to support growth of the conceptus, the gravid uterus, the mammary gland, and, with the onset of lactation, the nutrients needed for milk synthesis (Bauman and Currie, 1980).

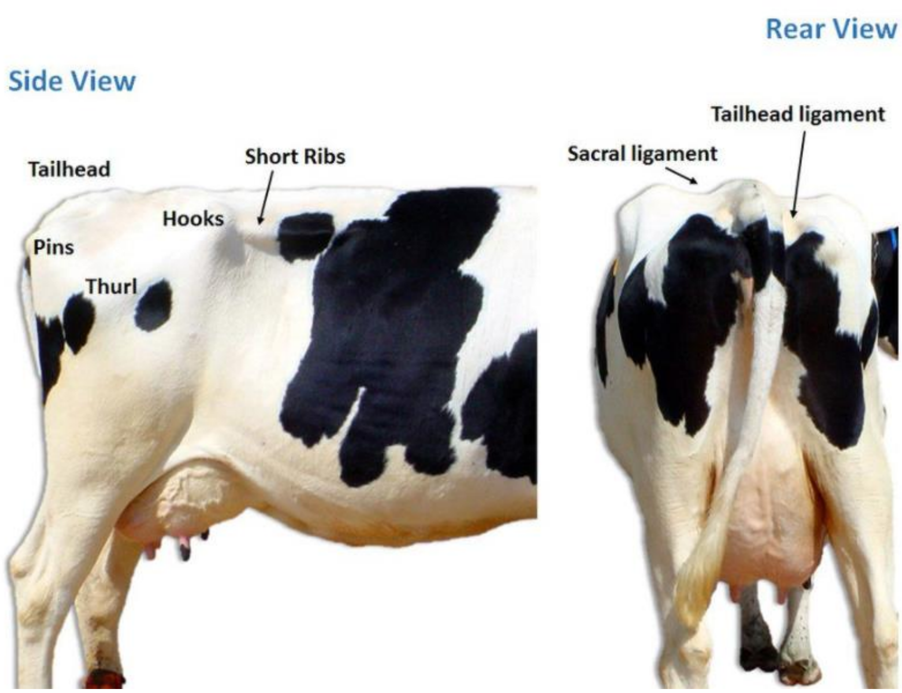
(4) Body Condition of Animal

Body condition scoring (BCS) for dairy cattle is on the same scale as beef cattle, 1 to 5. Typically, dairy cattle on pasture will have a lower BCS compared to confinement (Washburn and Mullen, 2014). Holsteins on pasture may experience a difficult time maintaining body condition score and drawing up on reserves more frequently than other breeds, such as Jerseys. Figure H-2 provides the side and rear view of the dairy cow; the BCS is measured using this area to focus on assigning the score. Table H-3 provides the suggested range for BCS by stage of lactation (Heinrichs et al., 2016). It is important to note that heifers will have a different BCS range for pre-breeding to calving. Ensuring the BCS is within range for the dairy cow is important to ensure reproduction and milk production are not impacted.

(5) Physiological State

(i) Pregnant pasture-based systems, particularly seasonal dairies using batch calving and lower input systems, can affect success in maintaining seasonal breeding and calving in Holstein and other breeds in those systems (Probert, 2012; Washburn and Mullen, 2014). There is a proportional increase in nutrient requirements during late pregnancy as the fetus grows exponentially and in preparation for lactation (Voth, 2018; Sguizzato, et al., 2020). Bell, et al., (1995) found the rates of increase of cow and fetus were linear or quadratic from 190d gestation to 270d of gestation. The crude protein increased from 62 and 117g/d, respectively.

Figure H-2. Side and rear view of dairy cow for body conditioning scoring (Heinrichs et al. 2021).



https://extension.psu.edu/body-condition-scoring-as-a-tool-for-dairy-herd-management#:~:text=Body%20condition%20scoring%20in%20dairy,indirect%20estimate%20of%20energy%20balance.

Table H-3. Cow BCS range

Stage of Lactation	DIM[1]	BCS Goal	BCS Min	BCS Max
Calving	0	3.50	3.25	3.75
Early Lactation	1 to 30	3.00	2.75	3.25
Peak Milk	31 to 100	2.75	2.50	3.00
Mid Lactation	101 to 200	3.00	2.75	3.25
Late Lactation	201 to 300	3.25	3.00	3.75
Dry Off	>300	3.50	3.25	3.75
Dry	-60 to -1	3.50	3.25	3.75

[1]Days in milk

Adapted from Heinrichs, et al., 2016.

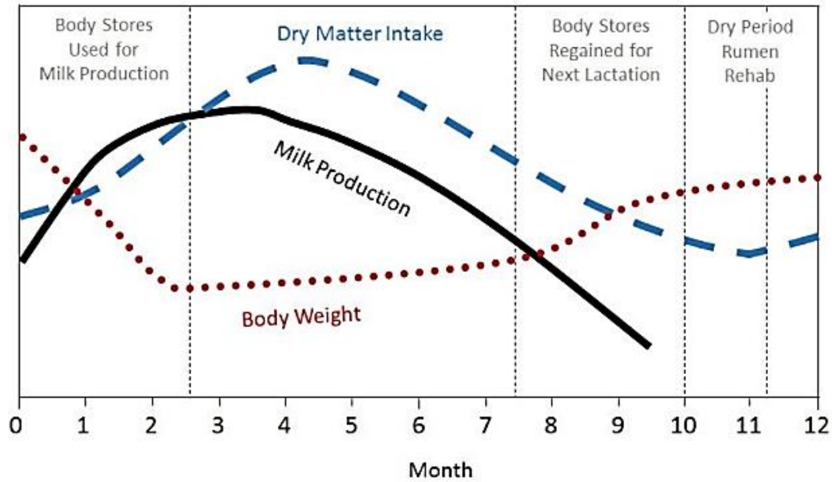
(ii) Physical Activity

- Pasture-based dairy cows will expend more energy than most confinement systems due to multiple circumstances:
  - the distance from the milking parlor to the pasture
  - grazing systems may have topography changes
- Pastured cattle will spend more time eating compared to the confinement fed cattle (NRC, 2001).NRC noted for a grazing 600kg (1,323 lb.) cow walking 0.5km (0.3mi) to and from the milking parlor 2 times per day (2km (1.2mi) total) the extra Net Energy allowance was 0.54 Mcal or about 5 percent increase in maintenance requirement. The additional increase does not include foraging in the pasture, walking to and from watering trough or if the pasture is hilly.
- Energy requirements will change along the dairy cow's production cycle, as is illustrated in Figure H-3. It provides an illustration of intersection between peak milk production and the start of increase for dry matter intake. At the same time there is a decrease in the cow's body weight to compensate for not only maintenance but milk production.
- Then there is a notable increase in body weight at the end of lactation, marked with a decrease in dry matter intake. If the forage does not provide sufficient energy and protein during peak production, then it is imperative that supplementation is provided. High producing cows require a higher plane of nutrition regardless of type of system; energy is the most limiting in pasture-based systems.

(iii) Lactation

- There are 3 main stages of lactation
  - early (14-100d)
  - mid (100-200d)
  - and late (200-305d)
- https://smallfarms.oregonstate.edu/sites/agscid7/files/feedingmilkingcow_1.pdf. Pastured dairy cattle typically have lower production per cow than nongrazing dairies, however, pastured dairies can be economically competitive due to lower operating and overhead costs (Washburn and Mullen, 2014).

Figure H-3. Energy requirements for a dairy cow (Heinrichs et al. 2021).



https://extension.psu.edu/body-condition-scoring-as-a-tool-for-dairy-herd-management#:~:text=Body%20condition%20scoring%20in%20dairy,indirect%20estimate%20of%20energy%20balance.

(6) Environmental Factors

(i) Feed

- Providing supplementation in an intensive grazing system can be challenging compared to confinement systems due to less control of the forage component with a grazing system. This reduces the consistency of nutrient intake from day to day and the variability in milk production Table H-4. The most limiting factor for dairy cattle is energy from forage alone.
- However, recent research has suggested that pasture based dairy cows may play a major role to supply healthier foods within systems with a reduced reliance on fossil fuels and chemical inputs, while also delivering environmental, biodiversity, and animal welfare benefits. (Delaby L., J.A. Finn, G. Grange, and B. Horan. (2020). Pasture-Based Dairy Systems in Temperate Lowlands: Challenges and Opportunities for the Future. Front. Sustain. Food Syst. 4:543587. doi: 10.3389/fsufs.2020.543587).

(ii) Water

Cattle obtain their water demand through three sources: drinking, ingestion of water contained in feed and water produced by the body's metabolism. Loss of water occurs through milk production, urine and fecal excretion, sweat and vapor loss from lungs (NRC, 2001). Lactating dairy cows will require 30 to 50 gallons/day. Water intake is very important since it reduces digestion of feed and feed intake, which then reduces milk production. It takes between 4 and 4.5 pounds of water to produce 1 pound of milk (Himmelmann and Amaral-Phillips). As temperatures increase so will water requirements.

(iii) Temperature

Heat and cold stress require the cow to increase the amount of energy used to maintain body temperature which requires an increase in the amount of energy the cow needs (Qi et al., 2015). Dairy cattle outside in adverse winter conditions will have a higher DMI and yet they grow slower or produce less milk due to the energy going to maintenance rather than production (Young, 1981). In 1981 the NRC estimated mild to severe heat stress requires increase maintenance requirements by

7 to 25 percent, respectively. Tucker et al. (2008) found Holstein Friesian cattle had a lower minimum body temperature when there was more protection from solar radiation using various levels of shade protection. Mild heat stress can occur at 65^{o} (Thomas, 2012), providing shade will minimize the production losses.

Table H-4. Lactation milk yield for Holsteins grazing and non-grazing farms.

Location	Grazing lb/cow	Non-grazing lb/cow	Difference
New York (2000)	17,107	19,006	1,899
New York (2001)	16,295	19,105	2,810
Northeast USA	16,227	18,218	1,991
Maryland (2000)	17,000	19,400	2,400

D. **Small Ruminants: Goats**.

(1) Goats have grown in consumer demand between 1999-2002 (Schweihofer, 2011) and United States research in this area is still growing, but not at the same rate as other ruminants. Developing countries have conducted more research in this area compared to the United States.

(2) Genetic Factors

Avondo et al., (2008) found Mediterranean type DM intake was strongly correlated with body weight and less correlated with milk production. Conversely, Alpine breeds' intake level was strongly correlated with milk production or body weight and weakly correlated with dietary characteristics. Silanikove observed differently with Black Bedouin breed, less affected by diet fiber content compared to Saanen goats, attributed to the higher microbial density and degradation rate for the Black Bedouin. The dairy breeds such as Nubian and Alpine will lactate for approximately 284 days, the volume and composition of milk is impacted by genetics, but diet consumed is greatly influential (Van Saun et al., 2008).

(3) Age of Animal

Dairy kids require approximately 21 percent higher energy needs than adult goat's maintenance requirements. Lactating does have the highest requirement for energy than any age (Rashid, 2008). Regardless of age, goats tend to forage on grasses high in protein and digestibility, then will browse if the browse is overall higher (Luginbuhl, 2000). For specific weight gain of 0.11 lb/day the NRC recommends an additional 0.03 lb of protein, 0.22 TDN, 0.002lbs Ca, 0.002 lbs of P. Increasing the weight gain to 0.22 lb per day requires doubling of the protein and TDN, however, Ca and P requirements remain the same (National Research Council, 2007; Spencer, 2018. Refer to table H-5).

(4) Body Condition of Animal

Similar to sheep, goats body condition scoring is on a scale of 1-5; 1 being emaciated and 5 being overweight and the 5-point check applies to goats (see figure H-4). Does should have a BCS of 3 to 3.5 to ensure fertility and good health when going into lactation.

Table H-5. Required Nutrient Concentrations: Daily Goat Rations per animal

Body Weight (lbs.)	Dry Matter (lb./head)	% Body weight	Total Protein (lb.)	TDN (lb.)	Calcium (lb.)	Phosphorus (lb.)	Vitamin A (IU)	Vitamin E (IU)
Maintenance								
22	0.63	2.80	0.05	0.35	0.002	0.002	400	84
45	1.08	2.40	0.08	0.59	0.002	0.002	700	144
67	1.46	2.20	0.11	0.80	0.004	0.003	900	195
90	1.81	2.03	0.14	0.99	0.004	0.003	1200	243
112	2.13	1.90	0.17	1.17	0.007	0.005	1400	285
134	2.44	1.82	0.19	1.34	0.007	0.005	1600	327
157	2.76	1.80	0.21	1.50	0.009	0.006	1800	369
179	3.05	1.70	0.23	1.66	0.009	0.006	2000	408
202	3.32	1.64	0.26	1.81	0.009	0.006	2200	444
224	3.58	1.60	0.28	1.96	0.011	0.008	2400	480
Additional Requirements for Late Pregnancy								
--	1.56	--	0.18	0.87	0.004	0.003	1400	213
Additional Requirements for Growth: Weight Gain at 0.11lb/day								
--	0.40	--	0.03	0.22	0.002	0.002	500	108
Additional Requirements for Growth: Weight Gain at 0.22lb/day								
--	0.79	--	0.06	0.44	0.002	0.002	500	108
Additional Requirements for Growth: Weight Gain at 0.33lb/day								
--	1.19	--	0.09	0.66	0.004	0.003	800	162

Spencer, 2018

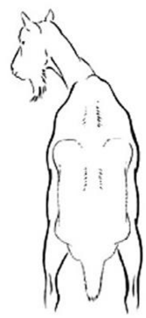
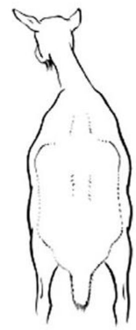
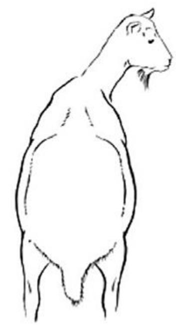
(5) Sex of Animal

(i) Developing and breeding bucks should be provided 1lb/d of a 16 percent protein mixture if forage or browse is limited or low protein (<10 percent; Luginbuhl et al., 2000). Aregheore (1994) found significant differences in growth rate for West African Dwarf goats between bucks and does when three different crop residues were fed, which indicated bucks had a higher rate. There was no impact on the voluntary intake for either sex. It is important to note those crop residues were in a tropical setting, but overall sex of the animal has an impact on growth rate.

(ii) FAMACHA© Scoring: FAMACHA© is an acronym for FAffa MAllan Chart, Faffa Mallan was the scientist who developed the chart shown in figure H-5. This technique is used to determine if the animal is anemic due to worms, specifically a symptom from barber pole worm. The scoring is based on a scale of 1 through 5, 1 being that the eye lid is bright red indicating low chance of worm infestation and indicates the producer should not deworm. A score of 3 is where it is questionable whether producer should deworm, and the producer will then move to a Five Point Check. The five-point check will include:

- eye (FAMACHA© score)
- back (body condition score)
- tail (dag scoring)
- jaw (bottle jaw)
- nose (nasal discharge)

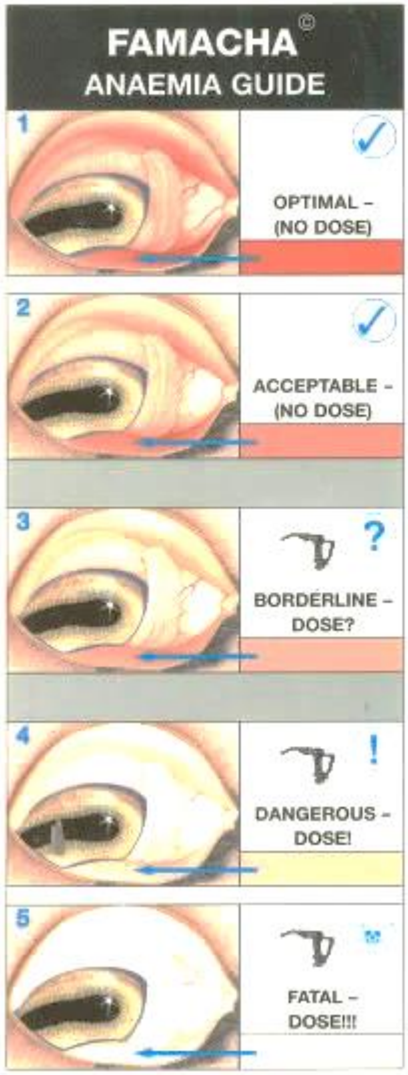
Figure H-4. Body Condition Score Description for Goats (Viera et al. 2015).

	Very thin	Normal	Very fat
General condition	Raw or slightly-raw boned goat, with backbone and some ribs visible.	Backbone not prominent but still visible and ribs difficult to assess visually.	Backbone and ribs not visible. Goat has a rounded appearance, sometimes with abdominal fat deposits visible.
Rump region			
	Hip and pin bones are prominent. The line that connects the hip bone and the thurl assumes a markedly concave shape. There is little muscle and/or fat between the skin and bone structures.	Hip and pin bones still visible, but not prominent. The line that connects the hip bone the thurl assumes a slightly concave or straight shape. It is possible to realize some muscle and/or fat between the skin and bone structures.	Hip and pin bones are difficult to identify. The line that connects the hip bone the thurl assumes a slightly or markedly convex shape. All the rump region is coated by muscle and fat, contributing to the rounded appearance of the goat.

(iii) A score of 4 indicates a must for deworming and a score of 5 is critical condition for the goat. A score of 5 the animal will need to be dewormed and monitored due to a high likelihood of death. These five-point checks will need to be conducted multiple times throughout the year. It is also recommended the producer conduct fecal egg counts to determine success of deworming. If an animal continues with re-infection of worms, the producer may need to consider culling the animal.

(iv) It is important to also consider the condition of the pasture. Pastures should be rested for at least 30 days and no more than 45 days to break the worm cycle, specifically the *Haemonchus contortus* (also known as the barber pole worm). Grazing height and stocking rate need to be controlled to avoid ingesting worms due to overgrazing. A stubble height of 4 inches should be achieved to reduce the chance of goats consuming worms that typically reside near the soil surface.

Figure H-5. FAMACHA© Scoring for goats (https://www.extension.purdue.edu/extmedia/AS/AS-573-W.pdf)(NCSU https://content.ces.ncsu.edu/forage-needs-and-grazing-management-for-meat-goats-in-the-humid-southeast#).



(6) Physiological State
- (i) Management and needs of goats depend on if the animal is being raised for milk, meat, or hair.
- (ii) Pregnant does are pregnant for approximately 150 days, roughly 5 months, which is affected by breed, kid weight, environment, and parity (Stewart and Shipley, 2014). Goats produce fat internally, which makes it difficult during pregnancy to have enough room to meet their nutritional needs (See table H-6), so it’s important to monitor does (Penn State University; https://extension.psu.edu/programs/courses/meat-goat/nutrition/feeding-the-doe/early-pregnancy-or-maintenance).
- (iii) Angora goats managed for mohair will require an increase in protein and TDN, this will be dependent upon the annual fleece yield for those animals (Spencer, 2018).
- (iv) Physical Activity

Similar to other livestock, goats' nutrient requirements will be dependent upon several factors, such as age, sex, production type (hair, dairy, meat), etc. (See tables H-6 through H-9). It is important to meet the goats' nutritional needs to ensure they are producing desired product and healthy. Growing kids require 21 percent higher rate for carbohydrates than adult goats (Rashid, 2008). Lactating does, growing kids, and mohair goats will have the highest energy and protein requirements (Rashid, 2008). Diary does require higher level of nutrition than non-dairy does. For example, a 132-lb doe's maintenance requirement for dairy doe is 0.72 lbs/d TDN compared to a 0.60 lbs/d for non-dairy and will consistently be greater throughout different cycles of breeding, gestation, and lactation (Schoenian, 2014).

Table H-6. Daily Nutrient Requirements for Meat Producing Goats.[1, 2]

Nutrient	Young Goats[3], Weaning (30 lb)	Young Goats[3], Yearling (60 lb)	Does, Pregnant (early) (110 lbs)	Does, Pregnant (late) (110 lbs)	Does, Lactating (avg. milk) (110 lbs)	Does, Lactating (high milk) (110 lbs)	Bucks (80–120 lbs)
Dry matter, lb	2.0	3.0	4.5	4.5	4.5	5.0	5.0
TDN, %	68	65	55	60	50	65	60
Protein, %	14	12	10	11	11	14	11
Calcium, %	0.6	0.4	0.4	0.4	0.4	0.6	0.4
Phosphorus, %	0.3	0.2	0.2	0.2	0.2	0.3	0.2

[1]Nutrient Requirements of Goats in Temperate and Tropical Countries, 1981. National Research Council.
[2]Pinkerton, F. 1989. Feeding Programs for Angora Goats. Bulletin 605. Langston.
[3]Expected weight gain > 0.44 lb/day.

(v) Lactation

Energy intake is the limited factor for milk production and will draw upon body reserves during early lactation to meet those requirements if feed intake lags nutrient demand (table H-7). Mid and late lactation and dry period can be made up during those periods to replace the stored energy (Sahlu and Goetsch, 1998). Upon kidding, the amount of grain may adjust upward 1-2 pounds grain, maybe more if nursing multiples (PSU; https://extension.psu.edu/programs/courses/meat-goat/nutrition/feeding-the-doe/early-pregnancy-or-maintenance). If a doe is a high milking goat grazing lush forage in early lactation it may be needed to provide a mineral with 20-25 percent magnesium oxide to reduce grass tetany (Luginbuhl et al. 2000). Also, if the forage or browse is limited or low in protein, they should be fed 1.0 lb/d of a 16 percent protein mixture.

Table H-7. Nutrient Requirements of Mature Does (Rashid, 2008), dry matter basis.

Production Stage	DMI, % of BW	% CP	% TDN
Maintenance	1.8–2.4	7	53
Early gestation	2.4–3.0	9–10	53
Late gestation	2.4–3.0	13–14	53
Lactation	2.8–4.6	12–17	53–66

Table H-8. Dry Matter Intake, Total Digestible Nutrient (TDN), and Crude Protein (CP) for a doe in late pregnancy with two kids. Nutrient Requirements of Small Ruminants, NRC 2006.

Live Weight (lb.)	Dry Matter Intake, Lb.	TDN %	CP %
66	2.23	79.21	15

(7) Environmental Factors [Source: Nutritional Feeding Management of Meat Goats. JM Luginbuhl. Oct. 8, 2015 (Revised: Sept. 17, 2020) North Carolina State University Extension].

(i) Feed

- Feeding may be the highest expense of any meat goat operation. Goats raised for meat need high quality feed in most situations and require an optimum balance of many different nutrients to achieve maximum profit potential. Because of their unique physiology, meat goats do not fatten like cattle or sheep, and rates of weight gain are smaller, ranging from 0.1 to 0.8 lb/day. Therefore, profitable meat goat production can only be achieved by optimizing the use of high-quality forage and browse and the strategic use of expensive concentrate feeds. This can be achieved by developing a year-round forage program allowing for as much grazing as possible throughout the year.
- The goat is not able to digest the cell walls of plants as well as the cow because feed stays in its rumen for a shorter time period. Trees and shrubs, which often represent poor quality roughage sources for cattle because of their highly lignified stems and bitter taste, may be adequate to high in quality for goats. This is so because goats avoid eating the stems, don't mind the taste, have the ability to detoxify tannins, and benefit from the relatively high levels of protein and cell solubles found in the leaves of these plants. On the other hand, straw, which is of poor quality due to high cell wall and low protein, can be used by cattle but will not provide even maintenance needs for goats because goats don’t utilize the cell wall as efficiently as cattle. In addition, goats must consume a higher quality diet than cattle because their digestive tract size is smaller with regard to their maintenance energy needs. Relative to their body weight, the amount of feed needed by meat goats is approximately twice that of cattle. When the density of high-quality forage is low and the stocking rate is low, goats will still perform well because their grazing and browsing behavior allow them to select only the highest quality forage from that on offer. Thus, they are able to perform well in these situations, even though their nutrient requirements exceed those of most domesticated ruminant species.
- Goats require nutrients for body maintenance, growth, reproduction, pregnancy, and production of products such as meat, milk, and hair. The groups of nutrients that are essential in goat nutrition are water, energy, protein, minerals, and vitamins. Goats should be grouped according to their nutritional needs to more effectively match feed quality and supply to animal need. Weanlings goats, does during the last month of gestation, high lactating does, and yearlings should be grouped and fed separately from dry does, bucks, etc. which have lower nutritional needs. When pasture is available, animals having the highest nutritional requirements should have access to lush, leafy forage or high-quality browse. In a barn feeding situation such as during the winter months, these same animals should be offered the highest quality hay available. Whether grazed or barn fed, goats should be supplemented with a concentrate feed when either the forage that they are grazing or the hay that they are fed do not contain the necessary nutrients to cover their nutritional requirements. Total digestible nutrients (TDN) and protein requirements are shown in table H-9. To give producers an idea where these requirements fall, low quality forages contain 40 to 55 percent TDN, good quality forages contain from 55 to 70 percent TDN, and concentrate feeds contain from 70 to 90 percent TDN.
- Because of a goat’s preference for trees and shrubs they are very effective in targeted grazing programs where shrubs or small trees need to be reduced either for invasive plant control or fuel (i.e. vegetation) reduction programs in wildland urban

interface areas for wildfire prevention. (Lovreglio, Raffaella & Ouahiba, Sahar Meddour. (2014). Goat grazing as a wildfire prevention tool: A basic review. iForest - Biogeosciences and Forestry. 7. 10.3832/ifor1112-007.) Ingham, C.S. (2014). Himalaya Blackberry (Rubus armeniacus) Response to Goat Browsing and Mowing. Invasive Plant Science and Management, 7(3):532-539.

Table H-9. Daily Nutrient Requirements for Meat Producing Goats. [1, 2]

Nutrient	Young Goats[3]		Does (110 lb)		Bucks (80-120 lb)	
	Weanling (30 lb)	Yearling (60 lb	Pregnant (Early)	Pregnant (Late)	Lactating (Avg Milk)	Lactating (High Milk)
Dry matter, lb	2.0	3.0	4.5	4.5	5.0	5.0
TDN, %	68	65	55	60	65	60
Protein, %	14	12	10	11	14	11
Calcium, %	0.6	0.4	0.4	0.4	0.6	0.4
Phosphorus, %	0.3	0.2	0.2	0.2	0.3	0.2

1 Nutrient Requirements of Goats in Temperate and Tropical Countries. 1981. National Research Council.
2 Pinkerton, F. 1989. Feeding Programs for Angora Goats. Bulletin 605. Langston University.
3 Expected weight gain > .44 lb / day.

(ii) Temperature

Like most mammals, goats can do a fairly good job of thermoregulation by eating additional food for energy, sweating, and panting (in extreme situations). In cold temperatures, goats can huddle to some extent to share body heat with each other and remain somewhat comfortable. The body temperature (rectal) of the goat ranges from 101.5 to 104°F. The thermoneutral zone of the goat is between 50 and 68 degrees.

(iii) Water

Production, growth, and the general performance of the animal will be affected if insufficient water is available. Water needs vary with the stage of production, being highest for early lactating does, and during times when the weather is warm, and forages are dry. In some instances, when consuming lush and leafy forages, or when grazing forages are soaked with rainwater or a heavy dew, sufficient water requirements for maintenance may be provided by feed alone. . Because it is difficult to predict water needs, goats should always have access to sufficient high-quality water. Clear, flowing water from a stream is preferable to stagnant water; the latter may contain excessive levels of blue-green algae, which may be toxic. Nitrate in drinking water should also be of concern because it is becoming the predominant water problem for livestock. Safe levels in drinking water are as follow (in parts per million): less than 100 for nitrate nitrogen, or less than 443 for nitrate ion, or less than 607 for sodium nitrate.

E. **Small Ruminants: Sheep**

(1) Genetic Factors

(i) Feed is a major cost in sheep production, Lee et al., (2001) estimated heritability of intake of mature ewes under pasture grazing conditions were low in Merinos, but much higher (0.4) in crossbred ewes (Fogarty et al., 2006). Merino sheep were found to have genetic and phenotypic correlations between feed intake and various production traits (Lee et al., 2002).

(ii) Improving ewe reproductive performance has been associated with greater profitability and life cycle efficiency than enhancing wool production or lamb growth (Wang and Dickerson, 1991; Borg et al., 2007; Murphy et al., 2020). Fogarty et al., (2009) studied heritability of feed intake of mature non-lactating and non-pregnant Merino ewes grazing pasture. The group found heritability for relative digestible dry matter intake was much higher than previous heritability for pasture intake for Merino sheep (0.32 and 0.12, respectively).

(2) Age of Animal

Intake changes in growing livestock as its size increases (Lewis and Emmans, 2010). The quantity of protein is more important than quality of protein since the rumen converts protein from amino acids (http://www.sheep101.info/201/nutritionreq.html). Young growing lambs and lactating ewes will have the highest requirements for protein due to muscle development and milk protein development, respectively. Energy and protein requirements on average are 15 percent higher for yearlings than for adult sheep due to yearlings' growth. Forage alone most likely will not meet the nutritional requirements for yearlings, which is similar for older ewes since their digestibility decreases with age (Ward and Gifford, 2017).

(3) Sex of Animal

(i) Prior to breeding (~10–14d) ewes will need to increase their energy intake, also referred to as flushing. Young rams require a higher plane of nutrition following the breeding season to replenish its condition (Greiner, 2005).

(ii) Entire ram lambs (not castrated) will grow faster, specifically Hampshire Down, Dorset, Suffolk, Charollais, Vendeen, or Texel-cross breeds. This can favor earlier slaughter, however, there could be a stronger flavor or taint to the meat (Hunt, 2015).

(4) Body Condition of Animal

(i) Throughout the production periods, producers should know the condition of their sheep, such as breeding, late pregnancy, and lactation. Weight at a given stage of production is the best indicator, but there is a wide variation in mature size between breeds and individuals, which makes body condition scoring an acceptable method to use (Thompson and Meyer, 1994).

(ii) Body Conditioning Score (BCS) can influence the response of an ewe to seasonal cues. Ewes with higher BCS display longer breeding rates because they are more likely to display estrus and experience a later onset of seasonal anestrous. However, it is unlikely manipulating BCS could shift the timing of the breeding season significantly. See figure H-6 (https://www.tandfonline.com/doi/pdf/10.1080/00288233.2013.857698).

(iii) Research trials at Oregon State University indicated an ewe BCS at lambing influenced total pounds of lamb weaned per ewe. If the BCS was 3 to 4 at lambing she lost fewer offspring and weaned more pounds of lamb than those with a score of 2.5 or less (Thompson and Meyer, 1994). Refer to tables H-10 and H-11. Data suggest there is an effect of BCS on return to service but there may be a genotype differences for the minimum BCS and the rate of return to service. There may be a minimum BCS above which the return to service rate decreases, there is also evidence that there is an upper limit to BCS above which conception rates can decrease. It appears that a BCS of 2.5–3.5, depending on breed, will result in a higher pregnancy rate, than a low or high BCS. A low or high BCS will negatively impact pregnancy rates. (https://www.tandfonline.com/doi/pdf/10.1080/00288233.2013.857698)

(iv) See also the FAMACHA Scoring for Goats.

Figure H-6. Body Condition Score and Description for Sheep (Bactawar, B. UF/IFAS Duval County Extension Service, University of Florida. https://extadmin.ifas.ufl.edu/nflag/livestock/sheep/sheep-nutrition/).

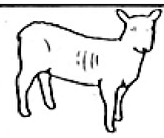
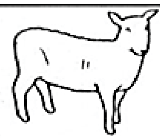
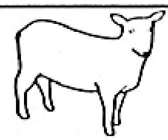
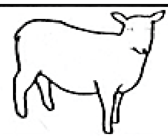
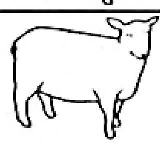
Score		Description	
1		Spine sharp, back muscle shallow,	Lean
2		Spine sharp, back muscle full, no fat	
3		Spine can be felt, back muscle full, some fat cover	Good Condition
4		Spine barley felt, muscle very full, thick fat cover	Fat
5		Spine impossible to feel, very thick fat cover, fat deposits over tail and rump	

Table H-10. Optimum BCS values at various stages of production (Thompson and Meyer, 1994).

Production Stage	Optimum Score
Breeding	3–4
Early–Mid Gestation	2.5–4
Lambing (singles)	3.0–3.5
Lambing (twins)	3.5–4
Weaning	2 or higher

(v) It is important to also consider the condition of the pasture. Pastures should be rested for at least 30 days and no more than 45 days to break the worm cycle, specifically the *Haemonchus contortus* (also known as the barber pole worm). Grazing height and stocking rate need to be controlled to avoid ingesting worms due to overgrazing. A stubble height of 4” should be achieved to reduce the chance of sheep consuming worms that typically reside near the soil surface.

Table H-11. Body weight by breed for ewes.

Breed	Classification	Approximate Mature Weight–Ewes[1]
Coopworth	Medium wool, meat	150
Dorset	Short wool, meat	140
Finnsheep	Medium wool, meat	120
Katahdin	Hair, meat	135
Polypay	Medium wool, meat	140
Ramboulliet	Fine wool, meat	150
Romanov	Black wool, meat	130
Shropshire	Short wool	150
St. Croix	Hair, meat	130
Targhee	Medium wool, meat	150

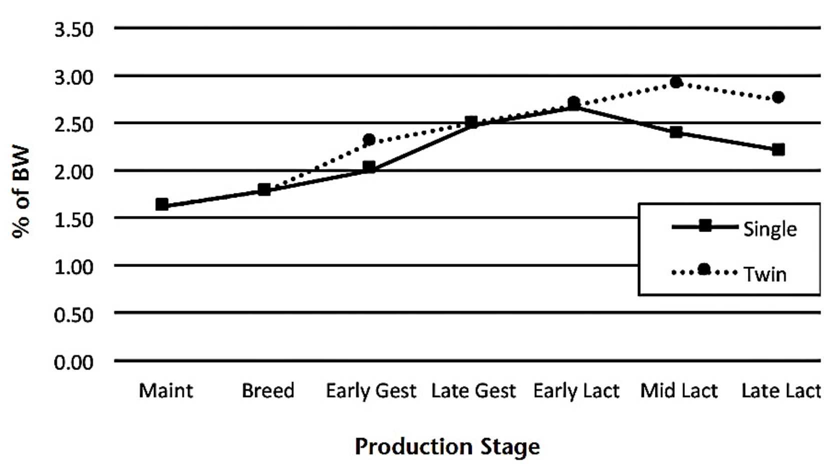
[1]Ram body weight is 1.55 to 1.75 times the ewe body weight.

(5) Physiological State

(i) Pregnant

Nutritional needs of an ewe will change largely with her stage and level of production (Ward and Gifford). Her energy needs are critical during breeding, just before lambing, and lactation, (figure H-7). shows the change in intake requirements over the ewes' productive year. Ewes should be at 3 or higher BCS to provide adequate energy for lactation. A 3+ BCS in the last part of gestation will be less prone to metabolic disorders (i.e. ketosis and pregnancy disease) compared to excessively thin or fat ewes. Fat or thin ewes may have low lamb birth weights and lamb vigor (Greiner, 2012). A low score could be due to nutrition or health concerns, such as parasites.

Figure H-7. Dry Matter intake of a 175-lb ewe (Ward and Gifford, 2017)



(ii) Physical Activity

The animal's basic maintenance requirements will vary based on age, exercise, climate, and body composition. Physical activity in grazing sheep can expend 10 to 100 percent more energy than sheep in drylots (New Mexico State University https://aces.nmsu.edu/sheep/sheep_nutrition/ewe_nutrition.html), the amount expended will depend upon topography and distance traveled to water and feed. Dry ewes will be able to maintain their nutritional requirements on pasture; however, supplementation may be needed during pregnancy and lambing, especially if used for dairy production. If the ewes are being used for milk production, they need a nutrition program with emphasis on body condition.

(iii) Lactation

A ewe will lose weight during early lactation. Weight loss will then taper off during mid-lactation and will regain weight at late lactation (Table H-11; Ward and Gifford, 2014). When an ewe has multiple lambs, the producer will need to prevent too much weight loss during lactation. It is recommended to either supplement or allow the lambs to creep feed.

(6) Environmental Factors

(i) Feed (Source: Sheep Nutrititon; Marcy Ward and Craig Gifford, Circular 685, College of Agriculture, Consumer and Environmental Sciences, New Mexico State University, 2017).

- Nutrition represents the largest cost in sheep production. A producer must know the animal's nutritional requirements during the different phases of production, the nutrient composition of available feedstuffs, and how to provide the available feedstuffs to meet the animal's requirements.
- Understanding the changes in nutritional requirements for sheep throughout the year will allow producers to fine-tune their nutrition program to reduce costs while maximizing production. Nutrition should be managed to support optimal health, be efficient and economical, and must minimize the potential for nutrition-related problems.
- The nutritional needs of a sheep do not stay the same. Instead, they vary largely with the stage and level of production. Energy needs are very critical (such as during breeding, immediately before lambing, and while lactating, during the various stages of growth and production). Other nutrients, such as energy, protein, vitamins, and minerals, will follow the same requirement pattern. Intake and nutrient demand will also increase with each additional need for production.
- One of the most reliable sources of information regarding sheep nutrition is Nutrient Requirements of Small Ruminants: Sheep, Goats, Cervids, and New World Camelids (2007), produced by the National Research Council (NRC). Requirements and diets of grazing sheep can vary greatly with changing forage quality and availability. However, if producers follow the NRC guidelines, the flock's nutritional requirements will be met as closely as scientifically possible at this time.
- Maintenance of the ewe is generally thought of in terms of her nutritional requirements when dry because at that time her requirements are the lowest of the year. Feed levels can be lowered to reduce the feed cost during the early stages of gestation and when ewes are dry. However, wool production is a continuous process that must be considered as part of the nutritional requirements throughout the year. The ewe's mature body weight will also affect how much feed she will need to simply maintain her condition. A ewe's nutritional priorities can be ranked: first is to maintain herself, second is to grow, third is for lactation, and last is reproduction. That means if the requirements for the first three stages of production are not met,

she will not reproduce. Therefore, proper nutrition is critical before, during, and after the breeding season. Ewes that have not had a properly balanced diet, including adequate phosphorus and vitamin A for example, may have a poor lamb crop percentage.

- **Gestation** is broken up into two phases: early and late. It is important to note that the nutritional requirements change throughout gestation. Therefore, feeding management may be fine-tuned to reduce costs and prevent ewes from becoming too fat or too thin.
  - Early Gestation (0–50 days)
    A ewe's nutritional requirements are only slightly higher than they are for maintenance. The goal should be to maintain good body condition in order to sustain the pregnancy. Significant weight loss at this time could result in early embryonic loss.
  - Late Gestation (105 days–lambing)
    -- Fetal growth is the greatest during the last 50 or 60 days of gestation.
    -- The nutritional status of the ewe should increase by approximately 20%.
    -- It is critical not to increase feeding overnight, but rather slowly over time before ewes reach this stage of pregnancy.
    -- If feed and body weight are not managed correctly at this stage, ewes can experience metabolic disorders shortly before or right after lambing.
- **Lactation** can be broken into stages: early, mid, and late. This can also help in management strategies for nutrition, weaning, and time of breeding. If the ewe's requirements are not adequately met for lactation, she will rapidly decline in her daily production. Once ewes experience a decline in milk production, due to interruptions in nutrition or water or reduced demand from the lamb, they will not regain their previous production level.
  - Early lactation
    The ewe's nutritional requirements continue to climb during early lactation. This period is generally considered to be the first 14 to 21 days after lambing. Additional protein and energy are required in order to maintain reasonable milk production.
  - Mid lactation
    The ewe peaks in her lactation cycle approximately 21 days after lambing. She requires both the greatest levels of energy and digestible protein during this time. Milk production gradually declines after this time as the lambs start to use more forage in their diet. Mid lactation is generally considered to be from 21 to 60 days after lambing.
  - Late lactation
    Late lactation is considered to be from day 60 to day 90 of lactation. By day 60, milk production is so low that it is no real benefit to the lamb(s) as a source of nutrition. Therefore, most production systems will wean their lambs at 60 days of age. If ewes are asked to milk too long, it could impede their ability to gain weight or to rebreed.
- **Young Lambs**
  - As with all growing animals, young lambs require a more nutrient-dense diet to properly meet their growth requirements. Lamb nutrition management can start before they are weaned. It is common in many sheep operations to creep feed lambs while they are still on the ewe. Creep feeding provides additional supplementation that the ewe cannot provide.

- Nutrition should be a priority with young growing ewe lambs. Separate management of these young animals may be necessary to optimize growth, genetic potential, and profitability. Additional supplementation is generally needed because native forages often fall short of meeting growth requirements.

- **Nutrition of the ram** should also be considered. A producer’s goal should be to increase a ram’s body condition prior to the breeding season since they tend to lose significant weight during the breeding season. If rams are over-conditioned, however, it may impact their libido and stamina for adequate breeding rates.
- On range and pasture lands, sheep will consume, in order of preference, forbs, grasses and shrubs and have been effectively utilized to control invasive species such as spotted knapweed, leafy spurge and yellow starthistle. Sheep on range or pasture can also be used as an alternative enterprise by taking value from wool, lambs or by contract grazing on other parcels of rangeland to control noxious weeds (Rinehart, L. 2008. Pasture, Rangeland and Grazing Management. A publication of ATTRA-National Sustainable Agriculture Information Service).

(ii) Temperature

The normal body temperature of the sheep is between 100.9° and 103.8°F. This temperature is in line with the normal body temperature of many other mammals. The thermoneutral zone (TNZ) for sheep, however, is between 70° and 88°F. This TNZ is almost 20 degrees higher than for most other farm animals. This higher TNZ is probably an adaptation to account for the amount of, and the insulating properties of the wool worn by the animal. The length and density of the fleece also affects energy requirements. Wool plays an important role in protecting sheep from both heat and cold. The insulating properties of wool help to cool the sheep in the heat of summer and keep body temperatures warmer in winter. Without wool, a sheep’s energy requirements would be higher. Finer wool breeds, for example, tend to be more adaptable to hotter, dryer climates. The more extreme the weather, the more nutrition the animal will require for maintenance. Using wind breaks, shade structures, and providing dry ground helps minimize reduced performance due to weather.

(iii) Water

Though there is no specific requirement for water, it is fundamental for life, health, and production. Clean, fresh water is a daily necessity for sheep and lambs. Sheep will consume anywhere from ½ to 5 gallons of water per day, depending upon their physiological state, the content of water in their feed, and environmental conditions. Requirements increase greatly during late gestation and lactation. Stage of production (growing, lactating, dry, etc.), air temperature, and water quality all affect water intake. It is imperative that fresh, clean, reliable water sources are made available at all times. Drought and also excessive moisture can greatly impact water quality. It is therefore important to monitor water quality through regular testing.

F. **Non-ruminants: Horses**

(1) Genetic Factors

(i) The grouping of horses includes horses, ponies, mules, and donkeys. Mules are a sterile cross between a female horse and a male donkey and are typically used as work animals. Ponies are actually breeds of small horses; ponies may be used as work animals or as pleasure animals.

(ii) Horses are large breeds of the species *Equus Ferus Caballus* and appear in many forms and have had many uses over the ages. Horses range from huge draft animals weighing over a ton to horses used for riding that weigh closer to a thousand pounds.

(2) Age of Animal

Foals are usually weaned at between 4 and 7 months of age, and actually begin eating small amounts of grass and grain at after 4 months of age. Horses can live to over 30 years of age with 20 to 25 years being the norm. Mares can become sexually mature at 12 to 15 months of age and stallions at 15 months of age. Mares can be bred at two years of age, though three years is more generally accepted. Mares can be bred and produce offspring throughout their adult life though time between foals may increase as the animal ages. Gestation period is generally between 320 and 380 days with smaller breeds adhering to the shorter time period. Stallions that will not be kept for breeding should be gelded between six and twelve months of age before they begin to exhibit stallion-like behavior such as aggression or unruliness.

(3) Sex of Animal

A newborn horse of either sex is called a foal. A young female that has not had a foal or is under three to four years old is called a filly. A mare is a female that has reached three or four years of age. A colt is a young male usually under three years old. A gelding is a male that has been altered by surgical removal of the testes to eliminate the aggressive behavior of a stallion. A stallion is an adult unaltered male.

(4) Body Condition of Animal

(i) The body condition of horses based on the degree of fat cover is a good indicator of a horse's general health. The body condition score (BCS) allows one to assess if the horse is too thin, too fat, or about right. See figure H-8. Horses are scored on a scale from 1 (poor) to 9 (extremely fat) in six areas where they deposit fat – neck, withers, spinous processes (part of back vertebrae that project upwards) and transverse processes (portion of vertebrae that projects outward), tail head, ribs, and behind the shoulder. The subjective assessment is based on visual and physical (palpation) of the specified body regions including the hooks (tuber coxae and hip joints) and pins (tuber ischia and lower pelvic bones). Comparisons of relative degree of fatness can be made within or between horses. Categorization of body condition as underweight (BCS $\leq$ 3, 1–9-point scale), moderate (BCS 4–6), overweight (BCS $\geq$ 7) or obese (BCS $\geq$ 8) can be used as an aid in the management of body condition for optimal health and performance

(ii) Advantages of the body condition score are:

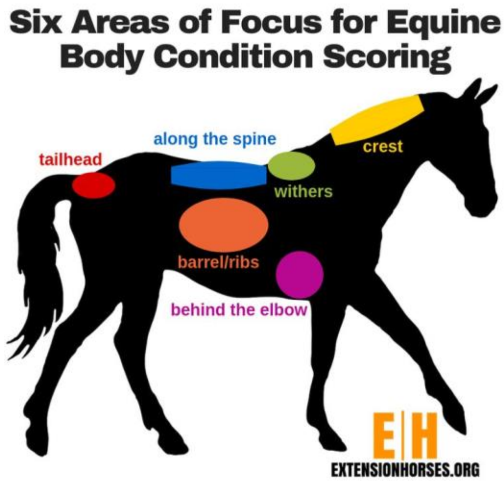
- Integration of all body areas
- Easy to perform
- Allows for classification of horses into underweight, overweight, or obese categories
- Cutoff values available to imply risk for disease
- Disadvantages of the body condition score are

(iii) Disadvantages:

- The method only assesses subcutaneous fat
- Bias between evaluators may influence results
- The score can be influenced by coat length, gut fill, muscle mass, pregnancy, etc.
- The score may not be comparable between different breeds or body types

Source: https://www.extension.iastate.edu/equine/body-condition-score

Figure H-8. Body Condition Scoring for Horses.



Source: Body Condition of Horses. CANR.MSU.Edu

(5) Physiological State

(i) Pregnant

- Mares can be bred at two years of age, though three years is more generally accepted. Mares can be bred and produce offspring throughout their adult life though time between foals may increase as the animal ages. Gestation period is generally between 320 and 380 days with smaller breeds adhering to the shorter time period. In feeding broodmares, consider several important factors: A good source of supplemental information for this area can be found at: Nutrition of the Broodmare, Cooperative Extension Service, University of Kentucky College of Agriculture. ASC 112. August 1988.
- Nutrient requirements of the particular class of horse being fed. Horses being worked, or large breeds, will require more and better feed than horses at rest. Mares, in the first and second trimester of pregnancy can probably get all or most of their nutritional needs from pasture and forage. As pregnancy progresses additional nutrients need to be provided.
- Physiological events involved in pregnancy. The physiology of the horse changes dramatically throughout pregnancy. Not only are there hormonal, structural, and physiological changes in the mare that need to be considered, but also consideration needs to be made for these same things in the developing foal. The foal grows from a single cell to around 45 to 50 pounds in less than a year of gestation, and this puts tremendous strain on all of the mare's physiological and anatomical systems.
- Nutrient content of the feed. The pregnant mare's nutrient needs are not much different from those of the mature horse at maintenance during the first two trimesters. Therefore, you can feed a pregnant mare a maintenance diet during early gestation. During the last trimester and during lactation, nutrient needs increase to meet the needs of the growing fetus and the newly born foal. If you are feeding a good quality alfalfa or legume hay, you may not need grain supplementation to meet the mare's nutrient requirements. However, feeding concentrate during the last 90 days of pregnancy is common and is a good practice to ensure adequate nutrition.

(ii) Physical Activity

As physical activity of the horse increases, its nutrient needs also increase. Mature animals, not performing work (work is draft, carriage, ranch, racing, pregnant, or lactating, among others) probably need little more than pasture and supplemental forage to remain in good physical condition. As the amount of physical activity increases, pasture and forage need to be supplemented with additional energy, protein, vitamins and minerals. These additional items may be supplied as whole feeds, concentrates, grain mixes, and mineral blocks, among other forms.

(iii) Lactation

Lactation is a period of substantial physiological stress. The lactating mare's nutrient needs are greater than those of any other class of horse with the possible exception of the horse in intense training. During this time the mare must recover from the stress of parturition, produce milk and re-breed. The lactating mare has an increased requirement for water, protein, energy, calcium and phosphorus. A normal, healthy mare will produce about 3 percent of her body weight in milk per day, during the first 3 months of lactation and 2 percent in late lactation. This means a 1000-lb mare will produce roughly 30 lbs of milk per day during early lactation and roughly 20 lbs per day during late lactation. Failure to meet the mare's nutrient needs during lactation will have more effect on her body condition than on milk production.

(6) Environmental Factors

(i) Feed

Because most horses in the US are kept through adulthood, they spend most of their lives needing energy for maintenance, with little additional energy needed for the small amount of work that they are doing. In most cases adult horses only need pasture or forage with very little supplementation. Working horses (draft, ranch, racing, pregnant or lactating) will need additional supplementation through grain, vitamins, and minerals. Pasture and range condition and makeup are very important to the health and wellbeing of the animals kept on them. Forage quality is important with working horses needing higher quality forages like alfalfa, and nonworking horses finding lower quality orchard or mixed grass hay sufficient.

(ii) Temperature

The horse is a warm-blooded animal like cattle, sheep, and even humans. If the horse receives sufficient energy from the food that it eats, it can withstand temperatures and weather conditions of most extremes. The "thermoneutral zone" (TNZ) for horses is about 41 to 77°F and for foals is around 60 to 72°F. This is the temperature range within the body that does not consume extra energy to maintain the internal body temperature. If the body has to set up mechanisms to warm up (shivering or slowing down of the respiratory rhythm) or to cool (sweating, increased breathing rhythm), it means that the horse is out of its comfort zone. The lower limit of this zone is the lower critical temperature and the upper limit is the upper critical temperature. Heavier breeds of horses (more body mass and greater degree of deposited fat) can withstand lower temperatures better than lighter breeds. The reverse is also true with lighter breeds able to withstand higher temperatures.

(iii) Water

An idle, 1,100-pound horse in a cool environment will drink 6 to 10 gallons of water per day. That amount may increase to 15 gallons per day in a hot environment. Horses that are being worked will drink more accordingly. Horses on fresh pasture that is high in moisture may have most of their water needs met by the grass that they eat. Quality of water is important for a healthy horse. The best indicator of water quality is total dissolved solids (TDS). The TDS sums the concentration of all substances dissolved in the water. The safe upper limit of TDS for horses is 6,500 ppm (parts per million or mg/L). Water below 1,500 ppm TDS is considered fresh water. Water greater than 5,000 ppm TDS is considered to be saline. Water quality can also be assessed by odor, color, and temperature. Odor is affected by the amount of sulfates, manure or rotting vegetation. An increase of any of these can affect palatability and voluntary intake (source: Water Quality for Horses, Iowa State University, Equine Extension).

G. **Non-ruminants: Poultry**

(1) Genetic Factors

(i) Three types of poultry are important commercially in the U.S. These are laying hens, meat type chickens, and turkeys.

(ii) Laying hens and meat type chickens are as different in breeding and function as are beef and dairy cattle. Poultry have been bred for quick growth and heavy production. Changes to the genetics of the bird can happen very quickly because hens reach laying age at about 5 months of age (7 months for turkey hens). Within another 3 to 5 months a generation of offspring will have grown and matured, providing data on which birds are the best producers. For instance, in 1980, it took 7 weeks to raise a 4-pound broiler, while in 2020 a 7-pound bird can be raised during the same time period. The same type of increase in production is exhibited in turkeys and laying hens.

(2) Age of Animal

Chickens and turkeys can live 5 years or more, but because production level falls as the birds get older, it is not economically feasible to maintain the birds to this age. Commercial laying hens are usually put into lay at 5 months of age and are rarely allowed to lay past two years of age. Turkey breeding hens start to lay at about 7 months and are rarely allowed to lay more than 8 to 10 months. Broiler breeding hens start to lay at 5 to 6 months and lay for about a year. Broiler chicks are marketed at a particular age based on the market the birds go to, with some birds for the fast-food market being harvested at 4 weeks, and roasters being harvested at as much as 10 weeks of age. Tom (male) turkeys are often grown to 25 weeks of age and 30 pounds and the meat from these large birds is processed into products such as turkey ham and pastrami. Turkey hens usually grow for 15 weeks and reach 12 to 18 pounds and are marketed as whole birds.

(3) Sex of Animal

The sex of the animal is most important with commercial egg layers. Because these birds are usually a light breed (usually White Leghorn), that has been bred solely for egg production, the male has little value and is usually sacrificed at hatching. Meat birds are often raised separated by sex to address a particular market to which the birds will be directed. With both meat type chickens and turkeys, males grow bigger and faster than females and sexes may need to be fed differently requiring different nutrients at a given time.

(4) Body Composition of Animal

(i) Poultry grow quickly and generally have a good ratio of lean-to fat. The dressing percentage for a commercial broiler is generally between 70 and 75 percent, compared to about 60 percent for a beef animal. Since laying hens, and breeding hens and roosters (and Tom turkeys used for breeding) are the commercial poultry that are used as adults, sometimes diets and feeding regimens need to be adjusted to keep the animals from becoming too fat. A high degree of fat can reduce egg production, fertility, and breeding ability.

(ii) Physiological State

The physiological state of a laying hen is always in flux. A hen in high production lays an egg about every 26 hours. About an hour after she lays, the hen ovulates, and lays again in another 26 hours. Hens on natural light usually lay before noon and rarely ovulate after about 3 pm in the afternoon. Because of this it is almost impossible for a hen to lay an egg a day. Egg production is largely a function of photoperiod, with hens needing 12 to 14 hours of light to be stimulated to develop an ovum, ovulate, and lay an egg. If the hen experiences decreasing daylength, she assumes winter is coming, and chicks she might hatch would not survive cold weather, so egg production will fall and eventually cease. For this reason, commercial hens never experience decreasing daylength; generally artificial lights are provided set to the time of the longest day of the year. The hen goes through all the same hormonal and physiological changes in the 26-hour period, that most other domestic animals experience in a 28-day (or longer) ovulatory cycle.

(iii) Physical Activity

Unlike most mammals, chicks are born active and with the ability to eat similar diets to the adult. Where they differ is that the chicks cannot thermoregulate and must be provided with warmth for the first two to three weeks of their life (chicks raised outdoors may need added warmth for a longer period of time). Correct environmental temperature of young chicks will affect their growth and production as they mature.

(6) Environmental Factors

(i) Feed

Both turkeys and chickens belong to the same taxonomic subfamily of Phasianidae (pheasants) which also includes quail and grouse, among others. All of these birds are characterized as ground living (though they may roost in trees) and spend much of their time scratching and pecking for seeds, worms, and insects. Very little of these animals' nutritional needs are met by forage and pasture, per se, but the seeds and insects that the pasture houses make pasture an attractive alternative for raising poultry. Around 5 to 10 percent of the birds needs can be met by eating grass or other plants, but since around 70 percent of the variable cost of raising poultry is for feed, this small amount attributed to pasture can have a sizable effect on the profit picture of the operation. If poultry are pastured, recommended stocking rates need to be followed and birds will be rotated frequently to prevent poultry waste from becoming a serious environmental problem (Fukumoto and Replogle (1999), Lee et al (2010), and Fanatico (2006). However, with proper management, there are significant benefits for soil health from pastured poultry. As birds roam freely on pasture, the manure is distributed back into the soil creating a nutrient-rich material for grass and pasture crops to utilize, which in turn provides food. Fukumoto and Replogle (1999) concluded that a properly managed pastured poultry operation would result in a decreased need for land application of fertilizers.

(ii) Temperature

Body temperature for both chickens and turkeys ranges between 105 to 107°F. Chicks are hatched at about 103°F, with temperature increasing each day for about 3 weeks until the normal range is reached; when normal is reached, chicks no longer need supplementary brooding heat. For most poultry, the TNZ is between 60 and 75º F. This zone represents the temperature range where heat production is lowest. As temperatures increase towards 85º F, the birds will adjust their behavior and decrease feed intake and production. These changes help prevent the bird's core body temperature from increasing. When air temperature increases towards 100º F, the birds' core body temperatures will increase to lethal temperatures unless relief is provided. Shade, ventilation, evaporative cooling, and providing feed late in the day (or at night when it is cooler) can all help to manage mortality due to high temperature.

(iii) Water

Water is the most important nutrient for poultry. Birds generally drink approximately twice as much water as the amount of feed consumed on a weight basis. During periods of extreme heat stress, water requirements may easily quadruple. Although the importance of providing adequate access to it is well accepted, the importance of good water quality is becoming ever more apparent. High levels of bacterial contaminants, minerals, or other pollutants in drinking water can have detrimental effects on normal physiological properties resulting in inferior performance. Drinking water should be clear, tasteless, odorless, and colorless. Poultry will do better on water that is slightly acidic than they will on water which is alkaline. Total Dissolved Solids (TDS) should have an absolute maximum of 2,999 ppm. (Source: Water Quality for Poultry, Auburn University Extension, June 2019).

H. **Non-ruminants: Swine**

(1) Genetic Factors

There are eight major breeds of swine that are commonly raised in the United States. Different breeds are better used for specific applications. Producers typically raise breeds that best fit their needs based on their qualities and physical characteristics. These eight breeds are: Berkshire, Chester White, Duroc, Hampshire, Landrace, Poland China, Spotted and Yorkshire. The modern pig grown commercially for meat is a fairly lean individual. Nevertheless, it will respond to a low-protein or high-fat diet by depositing more fat. Certain breeds such as the Chinese Meischan, the Gottingen minipig, and the feral Ossabaw have a much greater propensity for obesity. Obese lines of pigs have been developed by genetic selection for obesity-related traits such as maximal backfat thickness (Hetzer and Harvey, 1967; Mitchell, 2007 – reword). There are several reports where these breeds or genetic lines of obese pigs have been utilized as models for studies related to human obesity [see review by Mersmann (Mersmann, 1991; Mitchell 2007)].

(2) Age of Animal

Modern commercial swine have been bred for very fast growth, maturity, and harvest. From breeding of the sow to birth takes around 4 months, then around another 6 months are needed to produce a 260-pound market hog. Ten months is all that is needed for the entire life cycle of a modern commercial market pig. In many instances, producers who raise hogs on pasture use heritage breeds that have not been bred for the most efficient production. These animals grow slower, may grow at a less efficient rate of feed conversion, and may yield a carcass with a higher ratio of fat to lean. These animals seem to do better on pasture, and many consumers claim that the meat has more flavor. These animals may take over a year from breeding to market rather than the 10 months needed for commercial hogs.

(3) Sex of Animal

Swine sexes are further differentiated by size, gender, and ultimate use. Boars are adult males usually over one year in age, typically used for breeding. Sows are adult females used for breeding. Gilts are young females being raised for market or inclusion in the breeding herd. Barrows are young castrated males raised for market. If barrows are left intact, and reach sexual maturity, aggression can become a problem within the herd, and meat can have an “off” flavor when consumed.

(4) Body Composition of Animal

(i) Market swine have changed significantly over the years in response to market demand for less fat in meat. In the past, market hogs with 25 to 40 percent carcass fat were not unusual. In today’s commercial operations, body fat percentage closer to 15 percent is not unusual. By the same token, in the past to achieve market weight without a large degree of fattiness, hogs were marketed at around 220 pounds. Today’s pigs may be marketed at up to 280 pounds without being overly fat. This achievement to larger animals that are much leaner has been the result of breeding, nutrition, and management. See figure H-9.

(ii) Because producers of hogs on pasture often raise heritage breeds, those animals can be more typically higher in fat. The increased amount of exercise on pasture coupled with the low-calorie level of the small amount of forage eaten by pigs can moderate fat percentage somewhat.

(5) Physiological State

(i) Pregnant

- A sow will become sexually mature at 5 to 6 months of age, and the gestation period is about 115 days. The sow can produce about 2.5 liters per year. The purpose of the breeding herd is to consistently produce a targeted number of high-quality weaned pigs in an efficient manner and at low cost. The objective of the feeding program for gestating sows is to achieve an appropriate, targeted sow weight gain during gestation that will allow optimum litter development and prepare the sow for lactation.
- During gestation the pregnant sow requires nutrients and energy to maintain her bodily functions, for weight gain and to supply the developing litter (NRC 1998). Maintenance represents 75-85 percent of the total energy requirement of the pregnant sow. Maternal weight gain represents approximately 15-25 percent of the energy requirement of the sow. The composition of the maternal bodyweight gain will vary with parity, the amount of weight gained and the composition of the diet fed. Therefore, the energy cost per lb. of maternal gain can vary from 1.4-2.3 Mcal ME/lb (source: https://swine.extension.org/feeding-the-gestating-sow/; E-extension, August 28, 2019).

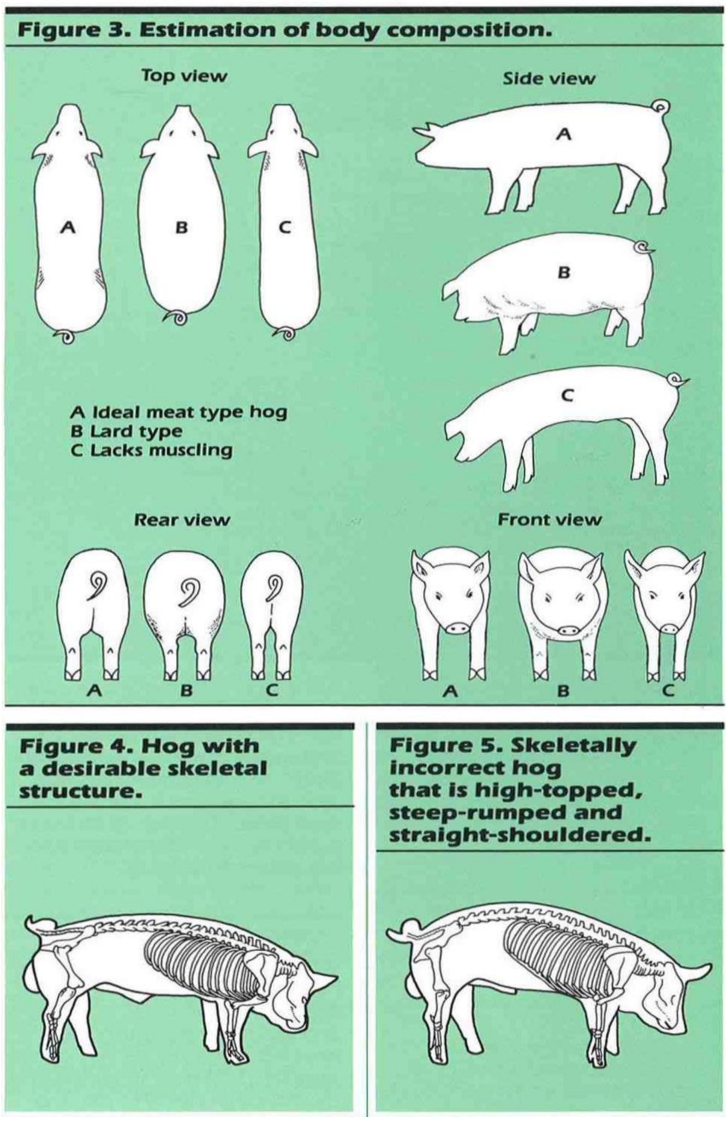
(ii) Physical Activity

Physical activity at all levels of production increases the need for food for the animal. Modern swine approach the best feed conversion of farm animals, falling behind chickens and turkeys, but feed conversion continues to improve.

(iii) Lactation

Sows require significantly more nutrients in lactation than in gestation to care for their litters without sacrificing body condition. The sow needs all the nutrients she can get during lactation. The more the sow eats the better potential she has for greater milk production, heavier litters at weaning and shorter time to return to estrus. The demand for energy and protein increases immediately following farrowing. Feeding sows *ad libitum* immediately allows them to consume the nutrients they require before they begin losing condition. On average, each sow consumes between 14 and 15 pounds of feed per day during the lactation period. Allowing the sows to eat what they need during lactation helps them to fulfill their needs on their own. This helps to minimize body weight loss during lactation, which, in turn, helps maximize piglet growth rates and optimize reproductive performance (https://www.purinamills.com/swine-feed/education/detail/sow-gestation-vs-lactation-rations).

Figure H-9. Hog body composition.



Source: 4-H 1064: 4-H Market Hog Project; Michigan State University Extension;

(6) Environmental Factors

(i) Feed

Swine are single stomached animals with a relatively short gastrointestinal tract. Feed must be digested and absorbed relatively quickly before it is expelled as waste. Because of this, swine must rely more on concentrated feedstuffs that are high in relative nutrients, than they do on grass and plants. Even pigs in the wild rely more on roots, nuts, seeds, worms, and insects for most of their nutrient needs than they do grass and plants. Though pigs need a concentrated diet, they can get at least some of their nutrition from grasses and forage. The growing hog can get up to 10 percent of its nutrient needs from pasture. Highly digestible plants or plants like legumes that are high in protein can supply a greater percentage of the nutrient needs of the animal. Most outdoor swine herds suffer from internal parasites that persist in soil; therefore, the producer needs to develop a rigorous parasite control program as part of a whole-herd health program.

(ii) Stocking rates

Stocking rates depend upon soil fertility, quality of pasture and time of year. Recently, several researchers (Rinehart 2018, Kephart et al 2019 and Pietrosemoli and Green 2015) have developed recommended stocking rates for pastured swine; however, pastured swine production systems can present significant environmental risks if not adequately managed. The environmental impacts of outdoor swine production are related to the natural behavior of swine and include deterioration of vegetative ground cover, soil compaction, high nutrient input, irregular nutrient distribution and nutrient losses to ground water and to the atmosphere (Pietrosemoli et al. 2012). Becchetti et al (2015) lists some of the management tools and approaches to help minimize the impact of swine. These tools include vegetative filter strips, hog proof fencing (permanent and electric), appropriate location of planned heavy use areas, and selecting appropriate vegetative cover for slowing, capturing, and filtering run-off. In addition, straw wattles and berm-and-swale systems can also be used to prevent overland flow and erosion from entering sensitive areas.

(iii) Temperature

The body temperature of a market pig is about 102°F. The thermoneutral zone (TNZ), the zone of temperatures at which the pig can maintain this body temperature without stress from being too hot or too cold is between 50° and 75°F. If temperature is greater than this range the pig will try to cool by decreasing food consumption, decreasing activity, finding shade, finding water, wallowing in mud, etc. If the temperature is lower, the animal increases activity, bunches together with other animals, finds protection from wind, and eats more food.

(iv) Water

- Water consumption ranges from less than 0.5 gal/ pig/day for newly weaned pigs to greater than 1.5 gal/pig/day for grow-finish pigs. Warm temperatures can quickly increase the consumption of water to much higher levels. High quality drinking water is an essential component for the health and efficient production of pigs.
- Many factors can affect the quality of water, including microbiological, physical and chemical factors. As a guideline, drinking water for animals should contain fewer than 100 total bacteria per milliliter and fewer than 50 coliforms per milliliter. Water should be clear and odorless. The acceptable range of pH is from 6.5 to 8.5. Total Dissolved Solids (TDS) for water for swine consumption should be less than 6,999 ppm. (Source: Guidelines for Water Quality in Pigs, North Carolina State University, Animal Science Facts No. ANS 00-811S, June 2000).

645.0804 Maintaining a Balance Between Livestock Numbers and Available Forage

A. The objective of most grazing management programs is to make optimum use of forage resources while maintaining or improving the resources. To accomplish this, a proper balance must be maintained between the number of animals using the forage and the amount and quality of forage produced.

B. No two years have exactly the same weather conditions. For this reason, year-to-year and season-to-season fluctuations in forage production are to be expected on grazing lands. Livestock producers must make timely adjustments in the numbers of animals or in the length of grazing periods to avoid overuse of forage plants when production is unfavorable and to avoid waste when forage supplies are above average. Timing of grazing and stock density should be managed to avoid overgrazing and yet achieve optimum proportion of plants grazed. In a rotation system, accomplishing this by changing the duration of grazing versus increasing stock density for the same grazing period can make overgrazing less likely to happen, especially when the producer has less experience with intensive grazing.

C. Avoidance of overgrazing is paramount and especially crucial during periods of rapid growth. Grazing management for the higher proportion of plants grazed can be implemented faster during periods of slow plant growth or dormancy, as the likelihood of overgrazing at this time is less. As producers gain experience with higher stock densities, shorter grazing periods can be implemented. Grazing a higher portion of plants helps to keep the vegetation more vigorous and reduces the buildup of old growth material. A livestock, forage, and feed balance sheet is useful in summarizing livestock and forage resources for use in planning and follow-through work.

D. The animal unit (AU) is a convenient denominator for use in calculating relative grazing impact of different kinds and classes of domestic livestock and of common wildlife species. (see table H-12). AU is generally one mature cow of approximately 1,000 pounds and a calf as old as 6 months, or their equivalent. An animal unit month (AUM) is the amount of forage required by an AU for 1 month. AU equivalents vary somewhat according to kind and size of animals.

(1) NRCS has elected to use 26 pounds of oven-dry weight or 30 pounds air-dry weight (as-fed) of forage per day as the standard forage demand for a 1,000-pound cow (one animal unit).

Forage consumption is affected by many factors and varies with individual animals. Some of these factors include:

- forage quality (crude protein and digestibility)
- standing crop
- age of the animal
- supplementation
- topography
- animal breed type
- animal species
- physiological stage
- weather factors
- watering facilities

(2) The National Research Council has calculated the requirements for a 1,100-pound dry beef cow to be 17.6 pounds per day. This is a calculated value based on a confined animal, and not what a 1,100-pound, free ranging, dry cow could eat to fill or capacity. Research has validated intake rates for beef cows as low as 1.5 percent of the body weight to a high of 3.5 percent. No single rate is always correct.

A free ranging 1,000-pound lactating cow grazing forage that is about 7 percent crude protein and 58.5 percent digestible would consume about 25 pounds of forage per day. If the forage quality is increased to 10 percent crude protein and 70 percent digestibility, forage intake would increase to about 32 pounds per day.

(3) Intake and stocking rates for lactating dairy cows are calculated at 3 percent of their body weight. Dry dairy cows are calculated using the 2.6 percent of body weight used by beef cattle. Table H-12 is a guide to AU equivalents.

Table H-12. Animal-unit equivalents guide (can be adjusted by actual weights).

Kinds / classes of animals	Animal-unit equivalent	Forage consumed, day	Forage consumed, month	Forage consumed, year
Cow, dry	0.92	24	727	8,730
Cow, with calf	1.00	26	790	9,490
Bull, mature	1.35	35	1,067	12,811
Cattle, 1 year old	0.60	15.6	474	5,694
Cattle, 2 years old	0.80	20.8	632	7,592
Horse, mature	1.25	32.5	988	11,862
Sheep, mature	0.20	5.2	158	1,898
Lamb, 1 year old	0.15	3.9	118	1,423
Goat, mature	0.15	3.9	118	1,423
Kid, 1 year old	0.10	2.6	79	949
Deer, white-tailed, mature	0.15	3.9	118	1,423
Deer, mule, mature	0.20	5.2	158	1,898
Elk, mature	0.60	15.6	474	5,694
Antelope, mature	0.20	52	158	1,898
Bison, mature	1.00	26	790	9,490
Sheep, bighorn, mature	0.20	5.2	158	1,898
Exotic species (To be determined locally				
Swine 55 pounds or more*	0.40	ND**	ND	ND
Swine < 55 pounds*	0.10	ND	ND	ND
Turkey*	0.018	ND	ND	ND
Broiler*	0.008	ND	ND	ND
Laying Hen*	0.012	ND	ND	ND
*Animal units here calculated from 40 CFR 122.23 EPA CAFO definitions				
** ND: No Data found for these animals				

(i) Some examples of computing animal unit equivalents are:

- 40 mature sheep = 8 animal units (40 x .2)
- 40 mature white-tailed deer = 6 animal units (40 x .15)
- 40 mature bulls = 54 animal units (40 x 1.35)

(ii) Livestock and wildlife summary and data sheet (exhibit 1) is a field tool to collect the data necessary for inventory, husbandry, and nutritional information.

E. Ability of cattle to adjust to fluctuating forage quality

The stomach of the domestic cow reaches full size and maturity by the time the animal is 4 to 5 years old. The size of the stomach and associated organs is dependent upon the nutritional level of the plants the animal grazes during this growth and development period. In areas where the nutritional level of plants is low, the stomach of a mature cow may become large enough to hold 40 to 50 pounds of air-dry forage per day to meet the nutritional needs of the animal. In areas where the nutritional level of vegetation is high, the cow's stomach is small because only 20 to 30 pounds of air-dry forage is required per day. The significance of these factors to livestock operators is:

(i) If the nutritional level of vegetation is low, more pounds of forage are needed per day to support the animal.

(ii) If domestic animals of any age are moved from a pasture of low-quality vegetation to one of high- quality vegetation, the performance response of the animals should be excellent.

(iii) If a mature animal is moved from a pasture of high-quality forage to one of low-quality forage, the digestible protein fraction of the forage the animal must consume rapidly decreases. The performance of the animal will be poor during this time lag. The young animal's performance may not become satisfactory until the animal reaches maturity.

F. Chemical factors affecting forage quality

Depending on the livestock type, animals grazing plants and within plant communities may encounter plant species that can cause low gains, poor reproduction, lowered consumption rates, and toxicity syndromes that can result in death. Toxins that affect animal intake include:

(i) Selenium—A mineral that accumulates by plants growing on soils with high content of this material. Usually only a small amount of plant material is toxic.

(ii) Glycosides—These toxins are in several groups. The most common form is prussic acid or hydro-cyanic acid (HCN). The materials result from cyanogenic glucosides. HCN is released from plants following freezing, wilting, or crushing.

(iii) Alkaloids—These molecules are thought to be utilized for plant defense and to prevent herbivory. Alkaloids will typically interfere with animal nervous systems. Animals generally cannot be treated to prevent these reactions.

(iv) Grass tetany

This condition is caused by a deficiency of calcium and magnesium caused by rapid growing plants during cold and cloudy weather, or a diet low in magnesium during a period of high need for this mineral.

(v) Copper

Should not be part of the mineral mix since it is toxic to sheep (U of ME).

G. Intake

(1) Intake declines as forage availability decreases. According to nutrient requirements for cattle (NRC), intake declines by 15 percent when forage availability drops below 1,000 pounds per acre. However, when forage availability is above this amount, then digestibility normally controls intake. Studies vary greatly, and reports range from 120 pounds per acre to 5,000 pounds per acre. This indicates that although forage availability is an important factor with regards to intake, it has a wide variety of conditions that change between types of animals and kinds of forage.

(2) Herbage intake has been expressed as components of animal behavior by the following equations. These equations provide a conceptual approach to understanding the characteristics of a pasture on the intake behavior and their interactions with animal variables.

(i) Daily herbage intake = Grazing time x Rate of biting x Intake per bite

(ii) Intake per bite = Bite volume x Bulk density of herbage in grazed area Bite volume = Bite depth x Bite area

(3) Biting rate and grazing time are often regarded as the main changes animals adjust if intake quantity is limited per bite. Animals increase grazing time to adjust for intake limitations.

Increasing grazing time is a short-term response and generally does not compensate for reduced intake.

H. Nutrient needs of animals

(1) Animals have a biological priority for nutrients as shown in table H-13. It is interesting in this summary that the animal naturally gives priority to feeding parasites and maintaining its existing condition, rather than prioritizing new growth and new life. The animal really does not give priority to the parasites—the parasites “take” from the animal and leave the animal the residual to meet its needs. This is one reason a parasite control program is so important to producers.

Table H-13. Biological priority for nutrients

Breeding female	Bull	Steer
Parasites	Parasites	Parasites
Maintenance	Maintenance	Maintenance
Fetus development	-	-
Lactation	-	-
Growth	Growth	Growth
Reproduction	Reproduction	-
Fattening	Fattening	Fattening

(2) Protein content

(i) Protein is required by rumen micro-organisms to digest forages; therefore, if protein is inadequate, intake will be reduced. Proteins are the principal constituents of the organs and muscles. Protein deficiency is also a major problem. If an animal has an energy deficiency, a lack of protein in its diet aggravates the condition. Protein supplement is often mistakenly advocated when total energy (carbohydrates and fats) intake should be increased. In many range- land areas in fair to excellent range condition, and where adequate dry roughage is available, protein supplement is the only winter supplement needed. See part H(8) for the importance of fecal sampling.

(ii) The qualitative protein requirement is greater for growth than for maintenance and is affected by sex, species, and genetic makeup within species. Most animals tend to eat to satisfy energy requirements. A shortage of protein or energy in the diet prevents the animal from using fully their potential for growth. As the growth rate of muscles and bones is limited, excessive energy intake is converted to fat. Protein is diverted to energy only when it is provided in excess of the metabolic requirement or calorie intake is sufficient.

(3) Carbohydrates

(i) The primary function of carbohydrates and fats in animal nutrition is to serve as a source of energy for normal life processes. The dry matter in plants consists of 75 to 80 percent carbohydrates. Carbohydrates are the major constituents of plant tissues, and the energy in most plants is available largely as carbohydrates. This energy provides the animal the nutrition for growth, maintenance, and production. Energy deficiency is a major problem and usually occurs when animals do not get enough to eat. Increasing the animals' total feed intake can bring about dramatic recovery from many so-called minor element deficiencies and diseases.

(ii) Maintenance requirements for dry animals are significantly less than those for lactating animals. About 20 days after an animal gives birth, the megacalories of energy required are 150 percent of those required before parturition. The needs of mother and offspring immediately before weaning are 200 percent of those of the dry mother.

(4) Vitamins and minor elements

In addition to carbohydrates, proteins, fats, minerals, and water, vitamins (organic compounds) are required by animals in small amounts for normal body functions, maintenance, growth, health, and production, and they regulate the use of major nutrients. Vitamins must be provided to animals for many metabolic reactions within cells. If the vitamins are not available, biochemical reactions cannot take place and such symptoms as loss of appetite, poor appearance, reduced growth, and feed utilization may occur.

(5) Minerals

(i) Minerals have three functions:

- Calcium and phosphorus are the main constituents of bones and teeth.
- Present as electrolytes in body fluids and soft tissues.
- Trace elements are integral components of certain enzymes and other important compounds. These trace elements serve as activators of enzymes.

(ii) Animals derive most of their mineral nutrients from forages and concentrate feeds they consume. The concentrations of minerals in forage depend upon the following factors:

- Species of plant
- Composition in the soil where plant is growing
- Stage of maturity
- Climatic conditions
- Agricultural treatments such as fertilizer and irrigation

(6) Importance of water on nutrition

(i) Water is a major component of the animal's body and is influenced by several such factors as species, age, and dietary conditions that effect the amount in the body. Animals are more sensitive to the lack of water than food. If water intake is limited, the first indication is feed intake is reduced. As water intake becomes severely limited, weight loss is rapid, and the body dehydrates. Dehydration with a loss of 10 percent is considered severe, and a 20 percent water loss results in death.

(ii) Insufficient or poor-quality water causes poor livestock performance. Water requirements are influenced by diet and environmental factors. Water consumption is generally related to dry matter intake and rising temperature (table H-14, figure H-10, and table H-15). As the temperature increases, water consumption increases and feed intake decreases. The three sources of water are:

- drinking water
- water contained in foods
- metabolic water

(iii) Green forages and silage contain 70 to 90 percent water and make significant contributions to the animal needs. Concentrates and hay contain about 7 to 15 percent water.

(iv) Metabolic water is produced by metabolic processes in tissues through the oxidation of nutrients within the body. The utilization by the body of ingested food substances and of tissue reserves yields among other things quantities of metabolic water. As the complete combustion of 100 gm. of fat produces about 110 gm. of metabolic water, whereas 100 gm. of carbohydrate yields only 55 gm. of water, fat reserves and fatty foods are believed to be particularly valuable as a protection against desiccation. This contention would appear to be supported by the fact that many animals which exist in deserts have large reserves of fat. (Mellanby, K. 1942).

(iv) Water quality and quantity are extremely important and can affect the animal's feed intake and animal health. Low quality water normally results in reduced water and feed consumption. New sources of water should be tested for nitrites, sulfates, total dissolved solids, salinity, bacteria, pH, pesticide residue, and other contaminants. Table H-16 is a suggested guide for water quality standards for livestock.

(v) Nitrites can kill animals if ingested in high enough dosages. They are absorbed into the blood stream and prevent the blood from carrying oxygen, thus the animal dies from asphyxiation. Nitrates at lower amounts cause reproductive problems in adults and lower gains in young animals. High sulfates and high total dissolved solids cause diarrhea. Toxicity caused by saltwater upsets the electrolyte balance of animals. Bacterial causes calf losses, reduced feed intake, increased infections, and diarrhea. Acidic water (< 5.5) or alkaline water (> 8.5) can cause acidosis or alkalosis. These affected animals usually go off feed, get infections easier, and have fertility problems. Pesticides are not directly harmful to livestock, but the meat or milk produced by them may be contaminated if not broken-down during digestion or eliminated from the animal.

Table H-14. Expected water consumption of various species of adult livestock in a temperate climate*

Animal	Gal./day
Beef cattle	6–18
Dairy cattle	10–30
Sheep and goats	1–4
Horses	8–12
Adult and market swine	1.5-3
Adult and market poultry	2X weight of feed consumed

*During heat stress situations, these upper limits can increase dramatically

Table H-15. Water requirements for swine by size of animal. Source: PSU Extension Swine Production Manual. June, 2005. https://extension.psu.edu/swine-production.

Animal	12-30 lb	30-75 lb	75-100 lb	100-240 lb	Sow & Boar	Lactating Sow
Intake (quarts/day/head)	1	2	5	6	8	10

Figure H-10. Water requirements of Indian and European cattle as affected by increasing temperatures (source: Winchester and Morris 1956).

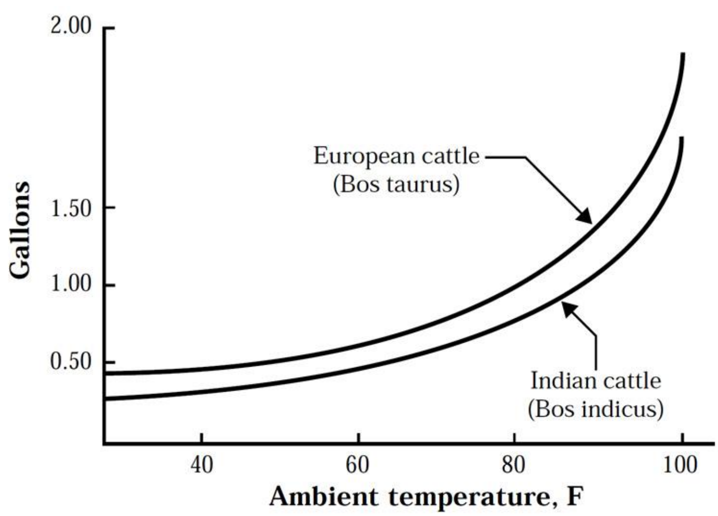


Table H-16. Water quality standards for livestock

Quality category	Limit to maintain	Upper limit production
Total dissolved solids (TDS), mg/L	2,500	5,000
Calcium, mg/L	500	1,000
Magnesium, mg/L	250	500+
Sodium, mg/L	1,000	2,000+
Arsenic, mg/L	1	?
Bicarbonate, mg/L	500	500
Chloride, mg/L	1,500	3,000
Floride, mg/liter	1	5
Nitrate, mg/liter	200	400
Nitrite	none	none
Sulfate	500	1,000
Range of pH	8.0–8.5	5.6–9.0
Salinity threshold concentrations in PPM		6,435 for horses 7,150 for dairy cattle 10,000 for beef cattle 12,900 for sheep

(7) Nutritional deficiencies in animals

(i) The two primary causes of nutritional deficiencies in animals are those resulting from poor management and feeding practices and those caused by low-quality forage resulting from mineral deficiencies in the soil. Nutritional deficiencies resulting from low-quality forage can be corrected rapidly by supplemental feeding. Inadequate protein is probably the most common of all nutrient deficiencies because most energy sources are low in protein and protein supplements are expensive. Correcting soil deficiencies by applying the needed minerals requires time for the soil and plants to respond before the nutritional deficiency is corrected. This is seldom an economically feasible option to supply minerals needed by grazing animals.

(ii) Nutritional profile of a cow year

Producers need to be aware of the nutritional requirements of livestock and how requirements change throughout the year as well as the changes in animal unit equivalents (AUE). Animal size, stage of production, production goals, environmental factors, and body condition influence the requirements through the year. Example 1 profiles of a 1,000-pound Hereford cow for a year. In the example, 1 month represents each quarter of the cow year.

(8) Fecal sampling

Application of Near Infrared Reflectance Spectroscopy (NIRS) analysis of fecal samples gives the manager the opportunity to review nutrient composition of the forage plants ingested by the animals. The analysis provides the manager a percent crude protein and percent digestibility in the fecal sample. This offers information to make necessary adjustments to feed amount and types.

Example 1. Nutritional profile of a cow year

Period 1. (May)
80 to 90 days post calving.
Most critical period in terms of production and reproduction.
Nutrient requirements are greatest during this period. If nutritional requirements are not meet during this period, the results are:

- Lower milk production
- Lower calf weaning weight
- Poor re-breeding performance

Animal unit equivalent = 1.00
Dry forage consumption = 26.00 oven dry weight pounds of forage per day. Calf is 0.06 AUE, and consumes 1.8 pounds of forage per day

Period 2. (August)
Cow is now pregnant and lactating.
Animal unit equivalent = 0 .9546 for this animal and 0.051 for the 90-day calf
Forage consumption = 23.98 oven dry weight pounds of forage per day for cow and 1.35 pounds of forage for the calf.
With a 200-day old calf, 6.9 pounds of forage.

Period 3. (November)
Post weaning and mid gestation. Animal unit equivalent = .91
Forage consumption = 23.8 oven dry weight pounds of forage per day

Period 4. (February)
50 to 60 days prior to calving. Fetal growth at maximum.
Animal is fed 1.5 pounds of 20 percent breeder cubes, 2.0 pounds of grade 2 corn, and 16 pounds alfalfa hay. Animal can graze free choice in the pasture.
Animal unit equivalent from the concentrates = .123, the hay is .54 and the forage in the pasture represents .23 for this animal during this period.
Consumption = 3.2 pounds of concentrate, 14.1 pounds of hay, and 5.9 pounds of dry forage per day from the pasture.

Young animals also have higher requirements to meet growth requirements plus maintenance.

645.0805 Feedstuffs

The composition of feedstuffs is broken into six fractions, five of which are determined by chemical analysis and the sixth (nitrogen-free extract) is determined by calculation of the differences of the other five. The six fractions are water, crude protein, crude fat, crude fiber, nitrogen-free extract, and ash. The actual feed values of a feed cannot be determined by only chemical analysis. Allowances for losses during digestion, absorption, and metabolism must be made., as well as overall cattle performance.

(1) Water content is determined for a feed by placing it in an oven at 105 degrees until dry or by drying in a microwave oven. Water content is used for analytical comparison of different feeds.
(2) Crude protein is calculated from the nitrogen content of the feed determined by the Kjeldahl procedure. Proteins contain an average of 16 percent nitrogen, so the crude protein is determined by multiplying the nitrogen figure by 100/16 or 6.25.
(3) Crude fat is determined by extracting the sample with ether. The residue after the evaporation of the solvent is the ether extract or crude fat.
(4) Crude fiber is determined by subjecting the ether extracted sample to successive treatments with boiling dilute acid and base. The insoluble residue remaining is the crude fiber.
(5) Nitrogen-free extract is made up of carbohydrates, such as sugars and starch.
(6) Ash is determined by burning the feed at a temperature of 500 degrees Celsius, which removes the organic compounds. The residue represents the inorganic compounds of the feed or the ash content.

645.0806 Husbandry

A. Supplementing forage deficient in nutrients. The purpose of supplemental feeding on grazing lands is to correct deficiencies in protein or other essential nutrients in the forage.

B. Protein supplement. The amount of protein supplement required per animal each season varies tremendously. Once protein supplemental feeding is initiated, the feeding rate must be sufficient to meet most of the animal's requirements and it must be continued until protein levels of available forage become adequate to meet the requirements of the animal. Insufficient amounts of protein supplement may be more detrimental to the animal's performance than no protein supplement. The micro-organisms in the stomach of a ruminant adjust to break down the low-quality proteins in dry mature forage. Introducing insufficient amounts of a supplement containing highly soluble protein alters the kinds and numbers of rumen microflora, so they become less effective in utilizing the less soluble protein of mature forage. The total amount of digestible protein used by an animal may thus be less than if no supplement had been fed.

(1) An example for feeding protein to cattle is 41 percent crude protein (CP) cottonseed cubes or 43 to 48 percent CP soybean meal (use caution in feeding cottonseed in excess due to toxicity, especially for immature lambs, calves, kids, and piglets). Feeding these protein supplements, coupled with adequate amounts of dormant vegetation, is generally an efficient method of providing supplements to cattle. If any supplement mixture other than the two mentioned is fed, consideration should be given to the following:
   (i) Cost per pound of digestible protein in mixtures, compared with that of cottonseed or soybean derivatives.
   (ii) Quality of the product.
   (iii) Effectiveness of mixture in balancing the needs of the animal with the kind of vegetation grazed.
   (iv) Possible detrimental effects of the mixture to domestic animals and big game animals.

(v) Value of added trace elements and vitamins in mixture.
(vi) Labor requirements.

(2) Feed additives

(i) A feed additive is an ingredient or combination of ingredients added to the basic feed mix or parts thereof to fulfill a specific need. Additives are used to stimulate growth or other types of performance or to improve the efficiency of feed utilization or be beneficial to the animal's health or metabolism. The various groups of additives classified as drugs include: antibiotics, nitrofurans, sulfa compounds, coccidiostats, wormers, and hormone-like compounds. Some additives reduce impacts on GHG emissions, refer to CPS 592 Feed Management.

- Antibiotics–These compounds are produced by micro-organisms that have the properties of inhibiting the growth or metabolism of organisms that may be toxic to animals. Two antibiotics approved in recent years are monensin (refer to label; especially if rotating cattle or goats with other livestock; fatal in sheep, turkeys and horses) and lasalocid, which are rumen additives. These additives shift the rumen volatile fatty acid production to propionic acid and a reduction of methane production, which results in more efficient and improved gain in growing and adult animals on pasture or forage.
- Feeding protein supplements–Methods of feeding protein supplements include:
  - Mixing salt with protein supplement to control intake.
  - Blending urea with molasses.
  - Use of protein blocks.
  - Use of range cubes or pellets (soybean or cotton-seed).
  - Use of cottonseed or soybean meal.

(ii) General feeding rules are:

- Substitute 3 pounds of corn silage for 1 pound of alfalfa-grass hay.
- Substitute 3 pounds of alfalfa-grass hay for 1 pound of grain.
- During winter feeding, provide warm drinking water in cold areas so that energy from the animal's body is not needed to warm the water. Livestock will drink more water, which improves general health and performance.
- Livestock shelter structures should be considered when weather stress is a factor; reducing impacts of weather stress will improve animal performance and feed efficiency.

  If riparian areas are used for winter protection, exercise caution or install measures to avoid excessive physical damage to the woody vegetation and streambank.

(3) Minerals and vitamins

(i) In some areas livestock may need minerals, such as phosphorus, calcium, or magnesium, and trace elements including manganese, selenium, molybdenum, copper, and iodine. To be effective, the minerals should be made available to both mother and off- spring.

(ii) Phosphorus supplements include dicalcium phosphate, steamed bone meal, or polyphosphate mixtures. They are normally fed in a mixture of one part of salt to two parts of supplement. If phosphorus is supplemented, calcium needs of the animals are generally satisfied. The calcium to phosphorus ratio needed by cattle is 2-parts calcium to 1-part phosphorus. Calcium is usually readily available, and supplemental minerals being fed should be at a 1 to 1 or 1.5 to 1 ratio, depending on livestock type.

(iii) Magnesium is very unpalatable and must be mixed with an enticer for animals to consume it.

(iv) Copper, depending on livestock type, is often needed as a trace mineral in peat soils, as found in some marsh rangelands.

(v) Vitamin A is often needed if animals graze mostly dormant, dry vegetation. The intramuscular injection is effective in providing enough amounts of vitamin A. It generally provides vitamin A for a 3-month period.

(vi) Local needs should be established, as applicable, relative to the kinds and amounts of minerals required.

C. Proper location of salt, minerals, and supplemental feed

Properly locating salt and minerals (and supplemental feed if required) in properly fenced and watered pastures encourages good distribution of grazing. They should be placed in areas to ensure that all parts of the pasture are uniformly grazed. Portable feeders permit salt and minerals to be moved from place to place in the pasture, thus making it possible to adjust grazing use according to utilization patterns. Salt and minerals should not be placed adjacent to livestock water. The number of salting locations needed depends on the size and topography (tables H-17 and H-18) of the pasture and on the number and kind of livestock using the pasture.

Table H-17. Approximate number of animals at one salting location to provide enough salt and minerals on different terrain.

Animal number	Type of terrain
40 to 60 cattle 125 to 200 sheep or goats	Level to gently rolling range
20 to 25 cattle 100 to 150 sheep or goats	Rough range

Table H-18. General salt requirements for grazing animals.

Animal	Pounds per month
Cows	1.5 to 3
Horses	2 to 3.5
Sheep and goats	0.25 to 0.5

645.0807 Control of Livestock Parasites and Diseases

Effective control of parasites living in and on livestock is needed for efficient livestock production. Some tools that aid in controlling parasites and diseases are:

(1) Grazing system designed to use grazing units or pastures during different seasons, periods, or months in subsequent years or in the same year aid in disrupting the cycle of internal parasites.
(2) Resting pastures for a minimum of 20-day periods and grazing plants no closer than 4 inches from the ground to break stomach-worm life cycles. Longer rests may be needed for more sensitive animals like goats and sheep.
(3) Clean water.
(4) Calving, lambing, or kidding at a period of the year when losses from parasites can be reduced.
(5) Adequate control programs to reduce parasite problems.
(6) Cattle dusters, backrubbers, and other insect-control devices. (These devices often help to improve grazing distribution and to control livestock movement.). For goats and sheep use the FAMACHA score card and change up the active ingredient.

645.0808 Regulating the Breeding Season for Efficient use of Forage

A. Controlled breeding program. For efficient use of forage, a breeding program should be compatible with the existing (or planned) forage production program. By controlling the time of breeding, the period of optimum growth for the animals to be marketed can be synchronized with the period of peak quality and optimum growth of forage. The local climate is often the limiting factor when attempting to correlate the breeding and forage production programs. Although NRCS personnel are not to make an issue of this fact, they should call to the attention of livestock producers the opportunities that controlled breeding provide, especially where it could result in an improvement in the duration and timing of grazing.

(1) Advantages of controlled breeding are:
- (i) Offspring are generally heavier at a given age and are in a better bloom at market time if they can graze throughout the growing season.
- (ii) Females are usually in better condition when they go onto mature forage. The herd winters with less care, and the need for supplemental feed is reduced.
- (iii) Animals are more uniform in size and quality at market time and generally demand better prices.
- (iv) Barren and sterile animals can be identified and eliminated rapidly.

(2) Disadvantages of noncontrolled breeding. Many livestock producers leave males and females together throughout the year. The disadvantages are:
- (i) Less efficient use of vegetation.
- (ii) Lower calving and lambing rates and greater difficulty in culling slow breeders.
- (iii) Higher labor costs.
- (iv) Greater feed costs.
- (v) Less efficient marketing because of nonuniformity in size of animals.
- (vi) Greater difficulty in manipulating livestock in planned grazing systems.
- (vii) Greater chance of adverse weather, both heat and cold, deterring optimum offspring growth.

B. Factors in planning a breeding program

(1) The following factors need to be considered in planning a program of controlled breeding:
- (i) Birth of offspring should be scheduled to occur when adverse climatic conditions are likely to be minimal.
- (ii) Variability in breeds and in the ability of their young to adjust to adverse climatic conditions.
- (iii) Parturition should occur when the chances of seasonal diseases and parasite problems are less likely.
- (iv) Female to male ratio; more bulls may be required for a 2- to 4-month breeding season to ensure adequate female exposure to available breeding males.

(2) Breeding season for ewes and nannies: Ewes and nannies are generally bred within a 60-day period (three heat cycles). Lambs and kids should be old enough at the time of vegetation green-up date to enable them to use the increased milk produced by their dams and to take advantage of the forage. If controlled breeding is practiced, one buck (ram) or billy is generally enough for every 25 to 30 ewes or nannies.

(3) Breeding season for cattle
- (i) The opportunity for a uniform calf crop may be obtained if the breeding period is limited to 60 to 90 days (3 to 4 heat cycles). Calving times should meet the operator’s objectives and correspond to the forage availability, supply, and nutrient content. Calving periods can start 60 to 90 days before the grass green-up date. The calves can take full advantage of increased milk production, and the cows will be in condition to

breed back. Breeding should start within 85 days after calving, or calves will be born progressively later each year.

(ii) If controlled breeding is practiced, one sire is generally adequate for every 20 to 25 females. The number of cows per bull ranges from 15 to 30 depending on the age, condition, management, libido, and semen quality of the bull; the size, condition, and topography of the pasture; and the distribution of the water supply.

(iii) Artificial insemination may be used in the cattle industry. A follow-up bull is generally used with each 100 cows to breed those that fail to conceive after one or two services.

(4) Reproduction characteristics. Table H-19 gives the reproduction characteristics of domestic animals. Table H-20 shows the ages of puberty for animals.

The practice of breeding for two calving and lambing seasons consists of dividing the breeding herd into two groups. One group is bred to calve or lamb in the fall and the other in the spring. Advantages include the need for fewer males and reduced labor requirements. This practice also permits two marketing periods.

(5) Additional factors in livestock breeding and selection

(i) All livestock should be bred, raised, and performance tested under the environmental conditions in which they are to be used. Because of the effects of heterosis, crossbred females usually reach productive ability at an earlier age, reproduce more regularly, and live longer, more productive lives than straight breeds of similar quality. Improved milking and mothering ability is another advantage of planned crossbreeding programs.

(ii) In selecting breeding animals for range and pasture, the following significant qualities should be considered. The list, however, is not in order of importance. For example, in Louisiana marshes we recommended that the most important quality is hardiness or environmental adaptability.

- Disposition
- Fertility
- Weight
- Rate of gain
- Conformation
- Hardiness, or environmental adaptability
- Milk production capability

Table H-19. Reproduction characteristics of domestic animals

Species	Heat period	Heat cycle (days)	Gestation period (days)	Females per male (number)
Horses	6–7 days	22	336-340	15-30
Cattle	12–18 hours	19.5	283	25 average
Sheep	29–36 hours	17	142-150	25 or more
Goats	24–26 hours	20–22	151	25 or more

Table H-20. Ages of puberty for domestic animals (U.S. conditions)

Animals	Age of puberty
Horses	Second spring (yearling)
Cows	5 to 13 months (depending on breed and condition)
Sheep	First fall
Goats	7 to 8 months

645.0809 Animal behavior

A. Knowledge of animal behavior is important to understanding the whole animal and its ability to adapt to various environments and management systems. The value and performance of animals can be increased when managers can apply their knowledge of animal behavior. The behavior of animals is a complex process that involves the interactions of inherited abilities and learned experiences to which the animal is exposed. Changes in behavior of the animal allow for adjustments to external or internal change in conditions. They also improve efficiency and survival.

(1) Behavior is a function of its consequences, and consequences of behavior depend upon heredity and environment. Managers that understand the behavior of animals can adjust their management and even train animals to be more efficient and effective in the areas they graze.

(2) Animals have instinctive reflexes and responses at birth and also learn by habituation to respond without thinking. Their responses to certain stimulus become established as a result of continued habits. Animals are also conditioned by responding to positive and negative responses. Animals learn or develop behavior patterns through various processes of trial and error, reasoning, and imprinting. The two kinds of conditioning are:

(i) Classical conditioning —learned association between a positive stimulus and a neutral stimulus. For example, when an animal sees you carry feed to them and then reacts the same way when the animal hears the door open in the barn where the food is kept.

(ii) Operant conditioning—learning to respond a certain way as a result of reinforcement when the correct response is made. Livestock avoiding an electric fence is operant conditioning.

B. Systems of behavior.

Animals exhibit several major systems or patterns of behavior:

(i) sexual
(ii) care-giving
(iii) care-soliciting
(iv) agnostic
(v) ingesting
(vi) eliminative
(vii) shelter-seeking
(viii) investigative
(ix) imitative behavior

C. The systems of behavior that most affect the animal well-being and productivity are ingesting, eliminative, and diet selection.

(1) Ingesting behavior

(i) Ingesting behavior is when animals eat and drink. Ruminants graze and swallow their food as soon as it is well lubricated. After they have consumed certain amounts they ruminate. Cattle usually graze for 4 to 9 hours a day and sheep and goats for 9 to 11 hours a day. Animals usually graze, then rest and ruminate.

(ii) Sheep rest and ruminate more than cattle. Cattle ruminate 4 to 9 hours a day and sheep 7 to 10 hours a day.

(iii) Cattle, sheep and horses have palatability preferences for certain plants, and have difficulty changing from one type of vegetation to another. Most animals prefer to graze the lower areas, especially near the water.

(iv) Age of the livestock and weather can also affect their grazing behavior. Cattle graze less when temperatures are low, and younger animals graze even less than older ones.

Colder temperatures also delay starting grazing times. Table H-21 shows the activities of a cow on winter range.

Table H-21. Behavior of a cow on winter range

Activity	Hours
Grazing	9.45
Ruminating, standing	0.63
Ruminating, lying	8.30
Idle, standing	1.11
Idle, lying	3.93
Traveling	0.58
Total	**24.0**

(2) Eliminative behavior

Cattle, sheep, and goats eliminate their feces and urine indiscriminately. Cattle defecate 12 to 18 times per day and horses 5 to 12 times per day. Both urinate 7 to 11 times per day.

(3) Diet selection

Herbivores are able to select a balanced diet, when given choices, even though their nutritional requirements vary with age, physiological state, and environmental conditions. The behavior of animals affects their response to nutrients in foods (intake and digestibility). As long as forage intake is not limited because of the quantity of forage, the primary factor influencing animal performance is forage digestibility. The behavior of animals affects their response to toxins in foods (toxicity).

645.0810 Exhibits

Exhibit 1. Livestock and wildlife summary and data sheet

Kind	Number of animals	Breed type	Class	Animal unit eq. or weight	Average body condition score	Age	Breeding age	Breeding period	Calving date	Grazing demand months	Roughage demand months	Supplement kind and Amount
Cattle	125	Angus	Cow	980	4.5	5–10	2.5 yrs	May–July	Feb–Apr	Mar–Nov	Dec–Feb	20% protein
Cattle	30	Angus	Heifer	600	5.0	2	2.5 yrs	May–July	Feb–Apr	Mar–Nov	Dec–Feb	20% protein
Cattle	7	Angus	Bull	1500	4.5	5	2.5 yrs	May–July		Mar–Nov	Dec–Feb	20% protein
Cattle	100	Xbreed	Steer	500	4.0	1				Mar–Nov		
Deer	50	mule	Mature	175				Nov	May	Jan–Dec		
Total	**287**			**201AU**						**9 mon.**		
Total AUMs										**1817.25**		

Worming schedule
Vaccination dates
Growth hormones
Shearing date

Livestock and wildlife summary and data sheet

Kind	**Number of animals**	**Breed type**	**Class**	**Animal unit eq. or weight**	**Average body condition score**	**Age**	**Breeding age**	**Breeding period**	**Calving date**	**Grazing demand months**	**Roughage demand months**	**Supplement kind and Amount**
Total												
Total AUMs												

Worming schedule
Vaccination dates
Growth hormones
Shearing date

645.0811 References

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