Chapter 6 Livestock Nutrition, Husbandry, and Behavior

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600.0600 General

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 livestock husbandry and livestock management principles and practices applicable to obtain proper and efficient use of grazing resources. They should not provide technical advice or assistance to livestock producers on matters relating primarily to animal breeding, genetics, or animal health problems (except when animal health is related to forage resources). Conservationists should acquire enough information about these matters to enable themselves to adequately discuss livestock health, nutrition, and behavior with livestock producers.

The greatest challenge associated with successful livestock management and in 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.

600.0601 Nutrition

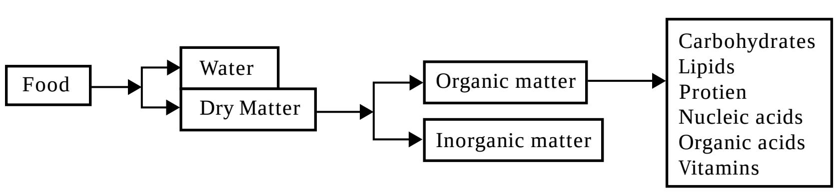
Developing a good feeding and management program is important for managers to meet livestock goals and herd performance objectives. Many factors affect the requirements of animals and the extent of nutrient utilization. The effect of genotype, physiological state, and environment on voluntary feed consumption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

When animals take in food of plant origin, 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). 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 6–1 for kinds of animals (beef and dairy cattle, sheep, goats, and horses) and representative breed types. The bulk of dry matter in plants is made up of three groups of organic compounds:

- Proteins
- Carbohydrates
- Fats

Carbohydrates, proteins, and fats (fig. 6–1) 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).

Figure 6–1 Components of a food



(a) Energy

The most important item in an animal's diet and overall feeding standards is based on energy needs. Meeting the energy requirements of an animal can be a major cost in feeding. Animals derive energy from partial or complete oxidation of carbohydrates, fats, and proteins ingested and absorbed from the diet or from breakdown of glycogen, fat, or protein absorbed in the body. Animals require some energy even in a nonproductive state for sustaining the body and maintaining body temperature and muscular activity. Additional energy is required when performing work and for growth and fattening, pregnancy, and lactation.

Energy is partitioned into various functions in terms of animal utilization (fig. 6–2).

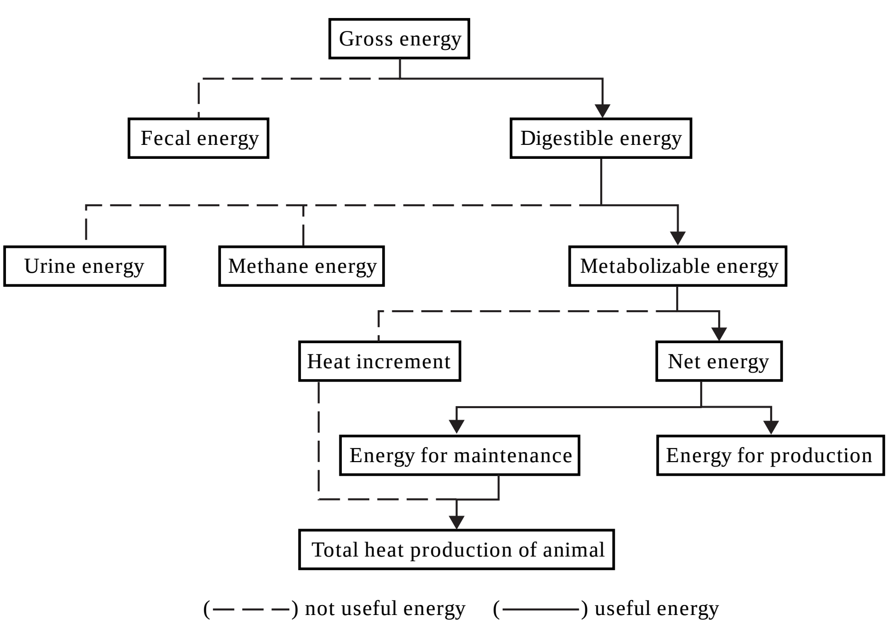
Gross energy (GE) is the amount of heat resulting from the complete oxidation of a food. GE values from feedstuffs are used in the process of evaluating energy utilization. Energy values and nutrients (carbohydrates, proteins, and fats) values vary in feedstuffs. The GE values for some feeds are given in table 6–1.

Digestible energy (DE) of a feedstuff is the consumed portion minus the fecal energy. Analyzing the fecal and feed energy allows for the calculation of DE. The energy lost in feces accounts for the single greatest loss of nutrients. Depending on species of animal and diet, fecal losses can be from 10 percent in milk fed animals to 60 percent for animals on poor quality diets.

Table 6–1 Gross energy values of feeds

Feeds	GE, KCAL/G
Corn grain	4.4
Wheat bran	4.5
Grass hay	4.5
Oat straw	4.5
Linseed oil meal	5.1
Soybean oil meal	5.5

Figure 6–2 Energy functions



Metabolizable energy (ME) is the gross energy of feed minus the energy in urine, feces, and gaseous products of digestion. The values of ME account for additional losses in the digestion and metabolism of ingested feed. ME is used to establish feeding standards because feces and urine are excreted together. Methane generally accounts for the most combustible gas in ruminant animals. In the fermentation process as much as 8 to 10 percent of the energy consumed is converted to methane. Diets low in quality result in larger proportions of methane, and the amount of GE lost as methane decreases as feed intake increases.

Net energy (NE) is equal to metabolizable energy minus the heat increment and the heat of fermentation. NE of a feed is the portion that is available to the animal for maintenance or other productive services. It accounts for most of the losses in metabolism of a feed or by the animal. NE is sensitive to changes in the environmental temperature as the animal leaves the thermoneutral zone (TNZ).

600.0602 Basal metabolism

Basal metabolism rate (BMR) may be defined as the condition in which a minimal amount of energy is expended to maintain the body. For an animal to meet the requirements for basal metabolism, the animal should be in the thermoneutral environment, a state of muscular repose, but not asleep and post-absorptive. Estimates of the needs for basal metabolism are that 25 percent of the energy needed is required for circulation, respiration, secretion, and muscle tone. The rest is the cost of maintaining electrochemical gradients across cell membranes and processes in replacement of proteins and other macromolecules.

(a) Factors affecting basal metabolism and voluntary intake

(1) Genetic factors

Part of the variations in the capacity for ruminants to consume feed has a genetic basis. 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 determined by the animal's genetic potential to use energy. For example, the Brahman breeds have a lower basal net energy requirement than British breeds, and a dairy cow has more soft tissue to maintain than a beef breed, making their basal net energy requirements higher. Table 6–2 gives some examples of breeds and energy adjustments.

Table 6–2 Energy adjustments for cattle

Breed	Energy adjustment
Brahman	– 20
British	+ 0.00
Dual purpose	+ 0.15
Dual purpose cross with beef	+ 0.10
Dairy	+ 0.20

Many studies indicate a significant voluntary consumption advantage of Bos tarus cattle (British breeds) over Bos indicus cattle (Indian breeds) under conditions of minimal environmental stress. The cross between the two breeds indicates a value intermediate to those of the parents. Voluntary consumption differences within and between species are clearly related to the animal's metabolic activity.

Voluntary feed consumption 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).

***(i) 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.

***(ii) 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 BMR of both sexes.

***(iii) Body composition of the animal*—**Body condition scoring (BCS) allows producers of livestock to evaluate animals with a scoring system that reflects reproductive performance. 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. Several factors affect body condition scores:
- Climatic conditions
- Stage of production
- Cow age
- Genetics
- Calving date
- Weaning date
- Forage management

The amount and kind of supplemental feeding required to meet performance are influenced by the initial body reserves of protein and fat. 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.

BCS is numbers to suggest the relative fatness or body composition of the animal. The scores range from 1 to 9 for beef cattle and horses and from 1 to 5 for sheep and goats. A body condition score of 5 or more (at least 14% body fat) at calving and through breeding is recommended for good reproductive performance for beef cattle. 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—The relationship between body condition scores and pregnancy percentage is demonstrated in figure 6–3. 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 sufficient time is allowed to recover body tissues.

Description of body condition scores—The different BCS ratings are described in table 6–3. Figure 6–4 shows the reference points for body condition scorings.

Figure 6–3 Relationship between BCS and pregnancy percentage

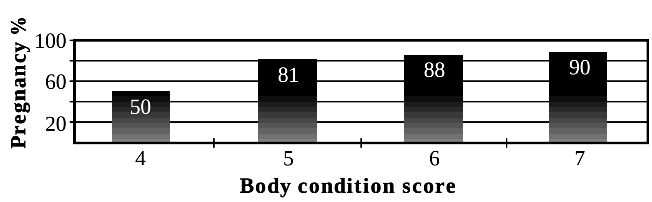
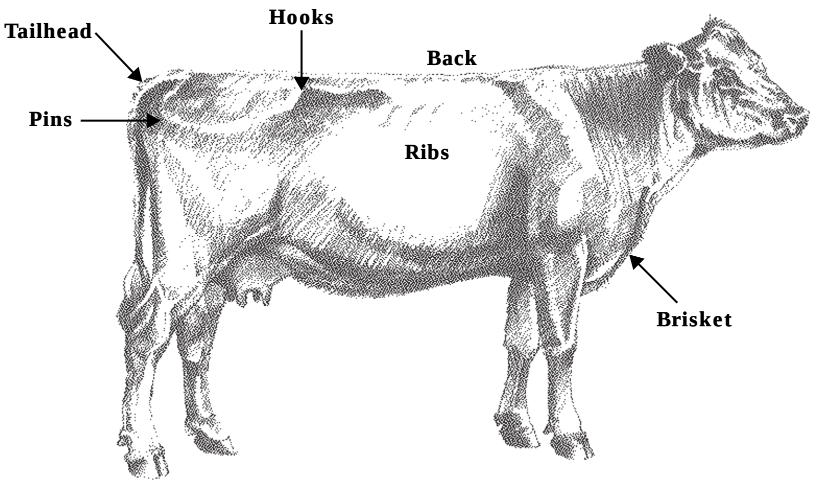


Figure 6–4 Reference points for body condition score



Reference points for body condition score

Table 6–3 Description of body condition scores

Body condition score	Description of cow
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 hindquarters. The backbone feels sharp to the touch.
3	Very thin, no fat on the ribs or brisket, and some muscle still visible. Backbone 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 can not 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. Animals mobility may actually be impaired by excessive fat.

(2) 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 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 cows peak lactation occurs in mature animals from 30 to 45 days after parturition and then gradually tapers off. This is why 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 carryover into the next pregnancy and the next lactation.

(3) Environmental factors

The climatic conditions browsing and grazing animals are exposed to can significantly affect the animal's intake. Most 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.

Animals loose 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.

(i) 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 6–4 shows typical TNZ's for different species.

(ii) 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.

(iii) 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 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 degrees and no night time cooling. At the same temperature with night time cooling, intake is reduced only 20 percent. Night time cooling allows animals to shift their grazing times to night, which can reduce time lost during the day.

(4) Forage quality and quantity

Forage intake is affected by several factors:

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

(i) 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 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.

Table 6–4 Typical thermoneutral zones

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

600.0603 Maintaining a balance between livestock numbers and available forage

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.

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.

Avoidance of overgrazing is important 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 nutritious 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.

(a) Determining animal-unit equivalents

The animal-unit is a convenient denominator for use in calculating relative grazing impact of different kinds and classes of domestic livestock and of common wildlife species. An animal unit (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 animal unit for 1 month. Animal unit equivalents vary somewhat according to kind and size of animals. States can, therefore, establish their own AU guides on the basis of locally available data relative to forage requirements.

The Natural Resource Conservation Service 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). This consumption rate is equal to 2.6 percent of the body weight. 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
- physiological stage
- weather factors
- watering facilities

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.

NRCS grazing lands software, Grazing Lands Applications (GLA), calculates forage demand and stocking rates at 26 pounds oven-dry weight per day per animal unit. This value represents a conservative value for NRCS work. 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 6–5 is a guide to AU equivalents.

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)

Livestock and wildlife summary and data sheet (exhibit 6–1) is a field tool to collect the data necessary for inventory, husbandry, and nutritional information.

(b) 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:

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

Table 6–5 Animal-unit equivalents guide

Kinds / classes of animals	Animal-unit equivalent	------ Forage consumed ------ day	month	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)				

- 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.
- 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. As much as a year may then be needed for adequate gut expansion for handling a compensating increased volume. 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.

(c) Chemical factors affecting forage quality

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:

- **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.
- **Glycosides—**These toxins are in several groups. The most common form is prussic acid or hydrocyanic acid (HCN). The materials result from cyanogenic glucosides. HCN is released from plants following freezing, wilting, or crushing.
- **Alkaloids—**These compounds cause physiological responses controlled by the nervous system. Poison is generally distributed throughout the plant. Animals cannot be treated with antidotes. The different types of alkaloids are:
  - — Phalaris
  - — Lupine
  - — Tall fescue
  - — Loline group of pyrrolizidine
- **Grass tetany—**This toxin is a deficiency of calcium and magnesium caused by rapid growing plants during cold and cloudy weather.

(d) Forage quantity

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.

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.

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

Intake per bite = Bite volume x Bulk density of herbage in grazed area

Bite volume = Bite depth x Bite area

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.

(e) Nutrient needs of animals

Animals have a biological priority for nutrients as shown in table 6–6:

Table 6–6 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

(1) Protein content

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 his diet aggravates the condition. Protein supplement is often mistakenly advocated when total energy (carbohydrates and fats) intake should be increased. In many rangeland areas in fair to excellent range condition, and where adequate dry roughage is available, protein supplement is the only winter supplement needed.

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.

(2) Carbohydrates

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.

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.

(3) 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.

(4) Minerals

Minerals have three functions:

- Calcium and phosphorous are the main constituents of bones, teeth, and other organs.
- 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.

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

(5) Importance of water on nutrition

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. In comparison, a 40 percent loss of dry body weight caused by starvation usually does not cause death.

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 (fig. 6–5 and table 6–7). As the temperature increases, water consumption increases and feed intake decreases. The three sources of water are:

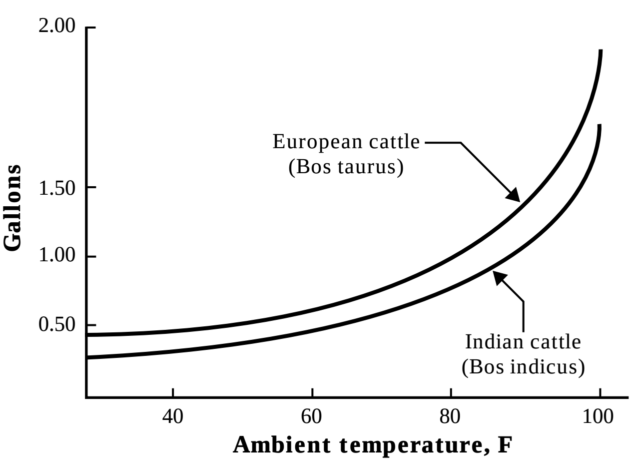
- drinking water
- water contained in foods
- metabolic water

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. Metabolic water is produced by metabolic processes in tissues through the oxidation of nutrients within the body.

Water quality is 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, and pesticide residue. Table 6–8 is a suggested guide for water quality standards for livestock.

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.

Figure 6–5 Water requirements of European and Indian cattle as affected by increasing temperatures (source: Winchester and Morris)



Water requirements of European and Indian cattle as affected by increasing temperatures. From Winchester and Morris (4).

Table 6–7 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

Table 6–8 Water quality standards for livestock

Quality category	Limit to maintain production	Upper limit
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	

(6) Nutritional deficiencies in animals

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.

***(i) 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 6–1 profiles of a 1,000-pound Hereford cow for a year. In the example, 1 month represents each quarter of the cow year.

(7) 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. The data can then be used in the nutritional balance analyzer in the Grazing Lands Applications Program.

Example 6–1 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 .06 AUE, and consumes 1.8 pounds of forage per day

Period 2. (August)
Cow is now pregnant and lactating.
Animal unit equivalent = .9546 for this animal and .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 is allowed to 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.

600.0604 Feedstuffs

The composition of feedstuffs is broken into six fractions (fig. 6–6), 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.

Water content is determined for a feed by placing it in an oven at 105 degrees until dry and is used for analytical comparison of different feeds.

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.

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.

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.

Nitrogen-free extract is made up of carbohydrates, such as sugars and starch.

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.

600.0605 Husbandry

(a) Supplementing forage deficient in nutrients

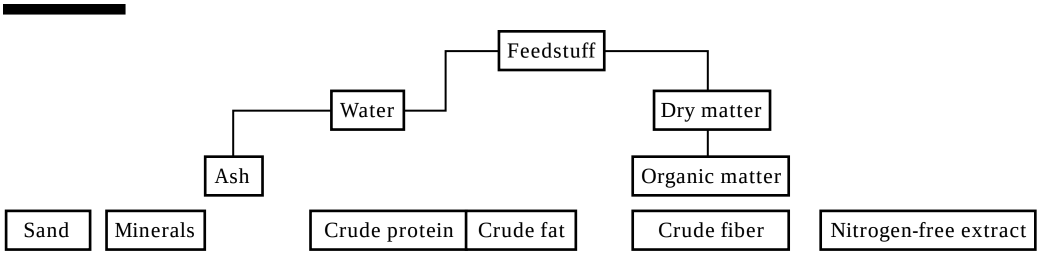
The purpose of supplemental feeding on grazing lands is to correct deficiencies in protein or other essential nutrients in the forage.

(1) Protein supplement

On most grazing lands dry standing forage does not constitute a balanced livestock diet. 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.

An example for feeding protein to cattle is 41 percent crude protein (CP) cottonseed cubes or 43 to 48 percent CP soybean meal. 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:

Figure 6–6 Fractions of a feedstuff



- Cost per pound of digestible protein in mixtures, compared with that of cottonseed or soybean derivatives.
- Quality of the product.
- Effectiveness of mixture in balancing the needs of the animal with the kind of vegetation grazed.
- Possible detrimental effects of the mixture to domestic animals and big game animals.
- Value of added trace elements and vitamins in mixture.
- Labor requirements.

(2) Feed additives

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.

(i) 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 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.

(ii) 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 cottonseed).
- Use of cottonseed or soybean meal.

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 then drink more water, which improves general health and performance.
- Provide sheds or windbreaks in cold regions to keep livestock from expending energy to maintain body temperature.
- 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

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 offspring.

Phosphorus supplements include dicalcium phosphate, steamed bonemeal, 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.

Magnesium is very unpalatable and must be mixed with an enticer for animals to consume it. Copper is often needed as a trace mineral in peat soils, as found in some marsh rangelands.

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

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

(b) 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 undergrazed 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 (table 6–9) of the pasture and on the number and kind of livestock using the pasture.

(1) Salt locations

Salt locations should be no more than 0.5 to 1 mile apart on rough range and no more than 1.5 to 2 miles apart on gently rolling range. (Requirements vary according to such factors as climate, area, kind of vegetation, and stage of growth.) Note: When grass tetany is a threat, Mg should be easily accessible to animals. Table 6–10 give the general salt requirements for grazing animals

600.0606 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:

- 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.
- 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.
- Clean water.
- Calving, lambing, or kidding at a period of the year when losses from parasites can be reduced.
- Adequate control programs to reduce parasite problems.
- Cattle dusters, backrubbers, and other insect-control devices. (These devices often help to improve grazing distribution and to control livestock movement.)

Table 6–9 Approximate number of animals at one salting location to provide enough salt and minerals on different types of 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 6–10 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

600.0607 Regulating the breeding season

(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.

(1) Advantages of controlled breeding

Advantages of controlled breeding are:

- 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.
- 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.
- Animals are more uniform in size and quality at market time and generally demand better prices.
- 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:

- Less efficient use of vegetation.
- Lower calving and lambing rates and greater difficulty in culling slow breeders.
- Higher labor costs.
- Greater feed costs.
- Less efficient marketing because of non uniformity in size of animals.
- Greater difficulty in manipulating livestock in planned grazing systems.
- Greater chance of adverse weather, both heat and cold, deterring optimum offspring growth.

(b) Factors in planning a breeding program

The following factors need to be considered in planning a program of controlled breeding:

- Birth of offspring should be scheduled to occur when adverse climatic conditions are likely to be minimal.
- Variability in breeds and in the ability of their young to adjust to adverse climatic conditions.
- Parturition should occur when the chances of seasonal diseases and parasite problems are less likely.
- 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.

(1) 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 or billy is generally enough for every 25 to 30 ewes or nannies.

(2) Breeding season for cattle

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 operators 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.

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.

Artificial insemination is sometimes used in the cattle industry. A followup bull is generally used with each 100 cows to breed those that fail to conceive after one or two services.

(3) Reproduction characteristics

Table 6–11 gives the reproduction characteristics of domestic 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.

(4) Additional factors in livestock breeding and selection

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.

In selecting breeding animals for range and pasture, the following significant qualities should be considered:

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

Table 6–11 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

The ages of puberty for domestic animals (U.S. conditions) are:

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

600.0608 Animal behavior

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. 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.

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. The two kinds of conditioning are:

- **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.
- **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.

Animals learn or develop behavior patterns through various processes of trial and error, reasoning, and imprinting.

(a) Systems of behavior

Animals exhibit several major systems or patterns of behavior:

- sexual
- care-giving
- care-soliciting
- agnostic
- ingesting
- eliminative
- shelter-seeking
- investigative
- allelomimetic

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

(1) Ingesting behavior

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

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.

Age and weather of the livestock 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 6–12 shows the activities of a cow on winter range.

Table 6–12 Behavior of a cow on winter range

Activity	Hours
Grazing	9.45
Ruminating	
Standing	0.63
Lying	8.30
Idle	
Standing	1.11
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).

Exhibit 6–1 Livestock and wildlife summary and data sheet

Example - 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			201 AU						9 mon.		
TOTAL AUM'S										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 AUM'S												

Worming schedule
Vaccination dates
Growth hormones
Shearing date