SUPPLEMENTATION CONSIDERATIONS FOR EWES MANAGED ON DORMANT WINTER PASTURES AND RANGELANDS

Key points

- Basal diets alone (pasture, hay, etc.) often do not meet nutritional requirements for all stages of sheep production.
- Forage nutritional value changes throughout the grazing season as plant maturity progresses.
- Ewe protein and energy requirements increase from breeding to late pregnancy, with greatest demands on ewes carrying more than one lamb.
- Forage availability (pounds per acre) needs to be determined on winter range to assess if a supplementation or substitution strategy should be employed.
- Calculating cost per pound of nutrient can ensure that supplement options are carefully compared on objective nutritional information to help make the most economical decision.
- Storage, feeding equipment, and target intake considerations should be carefully considered before purchasing supplements.

Why supplementation is necessary

Forage on rangelands of the Western US provide a cost-efficient way to raise livestock. Unfortunately, standing forages and harvested hay are highly variable in their nutritional composition, often falling short in meeting requirements of sheep flocks (NRC 1982, 2007). Seasonal quality of various western forages are displayed in Table 1, page 2. With many management scenarios and supplementation options across Western sheep production systems, it is important to understand some of

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the principles associated with effective sheep nutrition supplementation programs.

Meeting nutrient shortfalls

The objective of a supplementation program is to make-up for the nutrients (protein, energy, minerals, and vitamins) not provided in the grazing diet. Such a program may seek to overcome seasonal deficiencies by meeting requirements during physiologically demanding production periods for the ewe. Generally, standing forage is approximately one-third of the cost of harvested feedstuffs. Thus, a guiding principle is to maximize the use of your most cost-effective grazing resource, while utilizing the most affordable supplement that meets nutrient requirements. Overfeeding of a protein or energy supplement can potentially decrease time spent grazing and thereby reduce consumption of the most affordable feed resource. In contrast, during drought years where grazing forage resources are limited, energy supplementation can be utilized to decrease grazing pressure and potentially extend grazing resources.

Timing supplementation strategies to meet requirements for a specific stage of production is critical in an effective ewe supplementation program. A recent survey of Wyoming range sheep producers revealed that 73 percent of producers are reliant on dormant winter range for 90 to 130 days each year, which often overlaps with critical periods of breeding and gestation (Julian et al. 2020). Importantly, the naturally grown forage on rangelands is the least nutritious during this winter period. Sheep supplementation research determined that under most winter range conditions, sheep supplemented with protein at 0.25 to 0.33 pounds per-head per-day, or 0.2 to 0.3 percent of ewe body weight, did not reduce forage consumption, and that on average supplemented ewes weaned 5 to 10 more pounds of lamb per ewe than un-supplemented ewes (Thomas and Kott 1995). With the current feeder lamb price of $2.50 per pound (Fall 2021), supplementation could potentially result in an additional $12.50 to $25.00 per lamb.

Understanding protein and energy in grazing diets

It is important to note that protein and energy can both be limiting in the diets of livestock–either individually or simultaneously. Understanding which is the most limiting is a key factor in making a supplementation decision. Protein is a function of available nitrogen, and is the highest in green and actively growing plant material and the lowest in dry dormant plant material. Protein supply to the animal is provided both from dietary sources and the supply of microbial protein leaving the rumen and being absorbed in the small intestine. Thus, both protein and energy supplementation can help ensure that adequate rumen microbial supply is reaching the small intestine (NRC 2007).

Energy is a function of the amount of forage available because energy is ultimately derived from adequate dry matter intake and digestibility. Thus, if there is enough grass or desirable forbs and shrubs available, energy may not be the limiting factor. Dormant forages are often low in protein and consequently supplementing with protein will stimulate the rumen microorganisms and enhance the digestibility of the available forage and supply of microbial crude

Table 1. Seasonal forage value of common grasses

	Spring	Summer	Fall	Winter
		Warm Season		
Big bluestem	Good	Good	Fair	Poor
Little bluestem	Fair	Good	Poor	Fair
Blue grama	Good	Excellent	Good	Good
Sideoats grama	Good	Excellent	Good	Fair
		Cool Season		
Smooth brome	Excellent	Fair	Good	Fair
Green needlegrass	Excellent	Good	Good	Fair
Crested wheatgrass	Excellent	Fair	Good	Poor
Western wheatgrass	Good	Good	Good	Fair

Adapted from Sedivec et al. 2009, 2008.

protein reaching the small intestine. Low digestibility of dormant forage resources can constrain intake. Thus, even if there is an abundance of forage available for grazing, if it is of low quality sheep may not be extracting the necessary nutrients.

Understanding nutrient requirements for sheep

Meeting energy and protein requirements is vital for ewe productivity and lamb performance. From maintenance to peak (early) lactation, the desired dry matter intake (DMI) of a 154 lb. twin-bearing ewe increases by about 70 percent, and protein and energy requirements increase 158 and 111 percent, respectively (Table 2). Tailoring rations to ewe litter size can aid in precision management as twin-bearing ewes have a 26 percent greater energy requirement and 33 percent greater protein requirement during early lactation (NRC 2007).

Table 2. Daily dry matter intake (DMI), crude protein (CP), and energy (total digestible nutrients, TDN) requirements for ewes of various mature body weights across production periods carrying twins.

DMI (lb) for production period						
Ewe Weight (lb)	**Maintenance**	**Breeding**	**Early Gestation**	**Late Gestation**	**Early Lactation**	**Late Lactation**
132	2.0	2.2	2.9	3.24	3.55	3.53
154	2.6	2.9	3.7	4.04	4.37	4.41
176	2.9	3.1	4.1	4.39	4.74	4.83
198	3.1	3.4	4.4	5.91	5.12	5.23
CP (lb) for production period						
Ewe Weight (lb)	**Maintenance**	**Breeding**	**Early Gestation**	**Late Gestation**	**Early Lactation**	**Late Lactation**
132	0.17	0.21	0.28	0.38	0.62	0.40
154	0.19	0.22	0.30	0.40	0.64	0.42
176	0.21	0.24	0.33	0.44	0.69	0.46
198	0.23	0.26	0.36	0.51	0.74	0.50
TDN (lb) for production period						
Ewe Weight (lb)	**Maintenance**	**Breeding**	**Early Gestation**	**Late Gestation**	**Early Lactation**	**Late Lactation**
132	1.2	1.3	1.8	2.4	2.7	2.1
154	1.4	1.5	2.0	2.7	2.9	2.3
176	1.5	1.7	2.2	2.9	3.2	2.6
198	1.7	1.8	2.3	3.1	3.4	2.8

Adapted from NRC 2007.

As forage quality declines from September to December, preparing the ewe for lambing requires greater attention towards meeting protein and energy requirements. Ewes grazing dormant low-quality forage may appear full, which can be misleading as indigestible fiber and low crude protein (CP) content of diet will slow down the passage rate, resulting in a distended "full" appearance. As a rule of thumb, low-quality grasses with less than 7 percent crude protein require additional supplementary CP to aid rumen microorganisms' growth, and subsequent degradation of the low-quality forage.

Rumen volume restriction can occur due to fetal growth and resultant restricted capacity in the last third of pregnancy, especially for multiple-bearing ewes on a coarse forage-based diet. The combination of mature forages with high levels of indigestible fiber fed to prolific ewes should be monitored in the latter stages of pregnancy. Reducing particle size (chopped and pelleted supplements) to increase passage rate of feed material through the digestive tract can be a strategy to help ensure ewes consume adequate nutrients even during late pregnancy. High fetal growth demands for glucose can further put additional energy demands on the ewe, and strategic energy supplementation (e.g., 1/2 to 1 lb. corn, barley, or oats) per multiple bearing ewe per day, can prevent metabolic diseases and ensure optimal ewe performance (Table 2, page 3). Utilizing ultrasound scanning to identify multiple-bearing ewes will not only ensure adequate nutrients are consumed, but can save valuable feed and labor resources for the remainder of ewes that are not carrying multiple lambs.

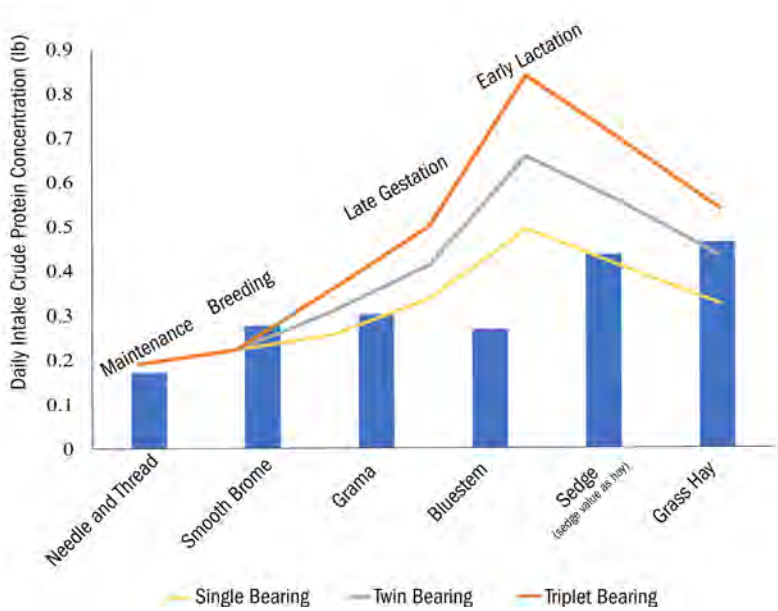

Figure 1. Protein concentration of mature forages compared to protein requirements of a 154 lb. ewe carrying a single, twins, or triplets at various stages of production (NRC 1982, 2007).

Winter grazing coincides with the most demanding production stages—late-gestation and early-lactation—often on the lowest quality feed resources. Additionally, if moving sheep to new pastures for the winter, sheep will be more selective in their grazing when first entering a pasture, with selectivity declining the longer the sheep are in a set pasture. Lower quality pastures should be grazed when nutritional requirements are lowest (e.g., maintenance), while greater quality and quantity pastures should be utilized during breeding and gestation. Stockpiling of pastures for breeding and gestation can allow ewes to select a higher quality diet and avoid potential nutrient restriction that can occur with continuous grazing in the same winter pasture.

While not reflected in standard sheep nutrient requirements, sheep may have up to 30 percent greater energy demand when grazing rangelands compared to sheep raised in confinement or housed production environment. The requirement to travel to seek out grazing and water sources increases the energy expenditure of sheep on pasture (Caton and Dhuyvetter 1997). Additionally, sheep on open range experience greater exposure to weather and temperature changes. The thermoneutral range for mature ewes is 24 to 66°F. This range, also known as effective ambient temperature, is the most comfortable range, or thermal-comfort zone, for the sheep. Their metabolic heat production is constant in this temperature range and that environment promotes maximum performance with the least heat or cold stress. Within the thermo-neutral zone there is a cool zone where physiological and behavioral changes take place to conserve body heat, for example, vasoconstriction of peripheral blood vasculature, adjustments in posture, and grouping together. Visual observation of some of these changes can help producers identify when animals are approaching cold thresholds. Yet, even with behavioral adaptations to alleviate lowering temperatures, once the lower critical temperature threshold is surpassed the animal must produce metabolic heat from dietary sources.

In general, the benefit of energy supplementation (e.g., from corn, barley, or oats) with grazing sheep is highly dependent on the quality of the pasture being grazed and the amount of energy being fed. Survey data sampled from Wyoming range sheep producers revealed that 90 percent of producers supplement their sheep while on winter range and 30 percent utilize whole corn as a main supplement source (Julian et al. 2020). Sheep supplemented with corn on low-quality pasture differ from cattle as sheep have been shown to increase their consumption of low-quality forage, whereas a reduction in intake is generally observed with cattle (Caton and Dhuyvetter 1997). This indicates that optimum corn supplementation when sheep are grazing low-quality forages is 0.25 to 0.50 percent of their body weight (Matejovsky and Sanson 1995). See Table 3 for estimation of optimal feeding rate based on ewe size.

Energy supplementation on pasture during late gestation has been shown to increase colostrum production and lamb survival (Banchero et al. 2009). Feeding ewes increased energy levels may have a greater effect on production than excess levels of protein. Additional protein may increase ewe condition and body weight during gestation, but has not been shown to increase lamb performance through weaning (Van Emon et al. 2014). Regular testing of basal diets, standing forage, or both will provide a quantitative estimate of what nutrients are being provided and what supplemental nutrients are required.

Much of western South Dakota and eastern Wyoming rangeland is mixed-grass prairie which can offer quality grazing for livestock. Knowing the plant community composition of your late season grazing resources can help guide supplementation strategies. The primary native forages in these areas are western wheatgrass, needle-and-thread, green needlegrass, big and little bluestem, buffalograss, sideoats grama, blue grama, and sedge species. These grasses can have different optimal periods of nutrition for livestock. For example, crested wheatgrass had peak CP in April while western wheatgrass had peak CP in July in a rangeland near Laramie, Wyoming (Scasta 2017). Most of the forages do not meet ewe nutrient requirements at all stages of production (Figure 1, page 4).

Table 3. Corn supplementation (0.5% of ewe body weight) recommendations based on ewe body weight and nutrient requirements met in early and late gestation for respective supplementation on low quality winter range.

Ewe Size (lb)	Maximum amount of corn supplementation before reduced forage intake (lb)	Daily energy requirements met in early pregnancy when corn is supplemented at 0.5% body weight (%)	Daily energy requirements met in late pregnancy when corn is supplemented at 0.5% body weight (%)
150	0.75	44	40
160	0.80	42	39
170	0.85	41	39
180	0.90	39	36
190	0.95	38	35
200	1.00	36	34

Assumptions: NRC (2007) requirements for ewe carrying twin lambs grazing winter range approximately from research results of Henning et al. (1980), Matejovsky and Sanson (1995), and Canon and Dhuyvetter (1997).

Primary non-native forages on rangeland in Wyoming and parts of western South Dakota are smooth brome, Kentucky bluegrass, and crested wheatgrass. Much of this range is shrub dominated and may include big sagebrush (Holechek, Peiper, and Gerbe 2004), and other browse species including silver sage, rubber rabbitbrush, saltbrush, and winterfat. Sheep are flexible in their preference for types of forages (e.g., grass, forbs, shrubs) depending on the availability and palatability of what is in the rangeland grazing environment. Generally, shrub species are greater in protein and minerals from late summer to winter compared to mature grass species. Thus, as a rule of thumb grazing lands with greater plant diversity (shrubs and forbs) provide greater nutritional composition than grass alone (Gade and Provenza 1986; Stewart et al. 2021). Although standing forage is cost-effective, the quality of forage resources will decline over the course of the growing season as plants mature. Similarly, a decline in quality and quantity of forage in a pasture occurs the longer the sheep are managed in the same pasture.

Supplementation versus substitution

Forage quantity should be determined prior to making a supplementation decision. Is there enough forage for your flock in your winter pasture? Have drought conditions limited standing forage from 1200 to 500 lb. of DM per acre? Similarly, adverse weather can limit or restrict grazing activity (e.g., snow depth burying forage and restricting movement). Many of these scenarios occur in Western US sheep production systems and can result in a supplementation program turning into a substitution program.

Generally, if there is inadequate forage available or it is inaccessible for grazing, that classifies as a substitution scenario where additional quantities (1 to 3 lb.) per head per day of additional hay or by-products need to be provided. This would be the case in a severe snowstorm where forage suddenly becomes unavailable under snow cover. Prior planning should account for unexpected substitution scenarios given the unpredictable nature of harsh winters. In contrast, when forage is adequate in quantity and accessible for grazing, but is of lower quality, supplementing with 0.25 to 1 lb. per head per day of protein or energy is required.

The most accurate way of estimating forage production on a given pasture or range is to take biomass clippings and archiving across years. However, another beneficial resource is the Natural Resources Conservation Service (NRCS) web soil survey (2019), https://websoilsurvey.sc.egov.usda.gov/App/HomePage.html. This free online and interactive resource allows you to identify your specific pasture from an aerial map or latitude and

Table 4. Forage availability for 500 ewes weighting 170 lb. each grazing a 640 acre winter pasture in a drought year (below average forage production) or a normal year production scenario (average forage production)

	Drought Scenario (Below Average Forage Production)	Normal Scenario (Average Forage Production)
Pounds per acre (DM Basis)	500	1,200
Pounds available per acre (50% utilization)	250	600
Total pounds available (50% utilization) on 640 acres	160,000	384,000
Pounds consumed per ewe per day	170 lb. x 2.5% of body weight = 4.25 lb. per day	170 lb. x 2.5% of body weight = 4.25 lb. per day
Grazing days per 500 ewes	160,000 lb. ÷ 4.25 = 37,647 lb. 37,647 lb. ÷ 500 ewes = 75 grazing days	384,000 lb. ÷ 4.25 = 90,352 lb. 90,352 lb. ÷ 500 ewes = 180 grazing days

longitude and can provide forage production estimates based on historical precipitation and soil data. This quick and easy resource also provides average forage production data, and above and below average estimates for high precipitation and drought scenarios. Utilizing university extension or other NRCS resources can also help you put together a plan. Another tool that has recently come available is the Rangeland Analysis Platform (RAP), https://rangelands.app/. RAP combines satellite imagery with ground data and now has annual biomass and 16-day biomass estimates from 1984 to 2021.

Annually evaluating the standing forage on your winter pastures is critical for determining when and how much you will need to supplement or substitute for forage shortfalls. For example, Table 4, page 6, shows two forage scenarios, where forage production in a drought year is 40 percent of a normal year resulting in 105 fewer grazing days (75 grazing days in a drought year versus 180 grazing days in a normal year). In this scenario, a pasture that would easily maintain 500 ewes for a winter season in a normal year is drastically reduced, and strategies to either reduce the number of ewes grazing or procure hay supplies to carry the flock are warranted.

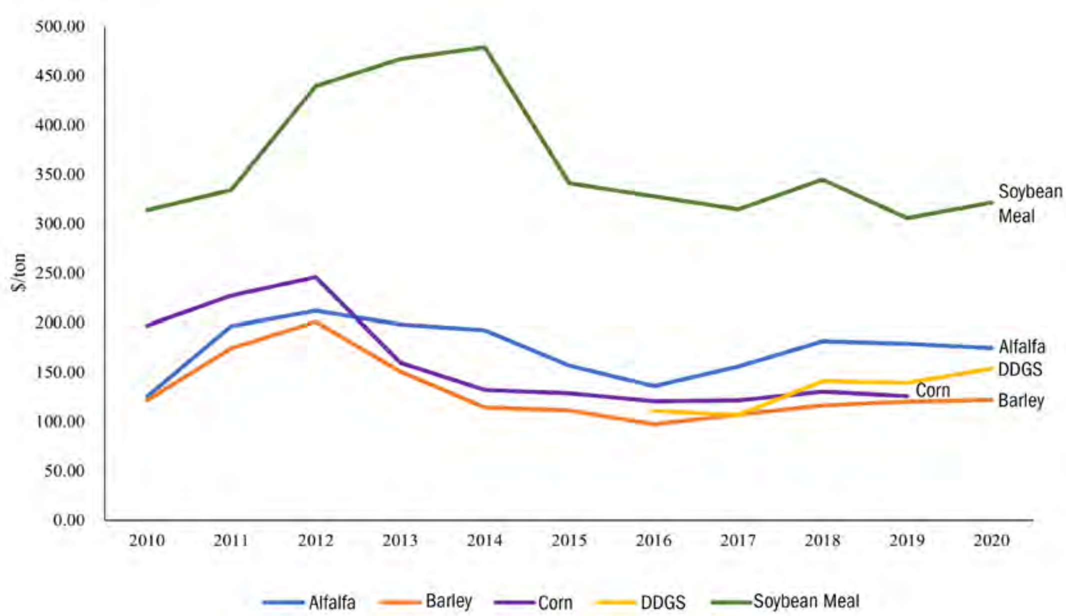

Figure 2. Historic prices of supplemental feed stuffs (LMIC 2021).

Supplement options and cost per pound of nutrient

With a variety of supplementation options, the starting point is finding available options for your region that complement the available forage resources. Alfalfa hay, corn, barley, and dried distiller grains (DDGS) have traditionally been used for supplementation and are generally widely available and cost-effective (Figure 2, page 7). Additionally, emerging non-traditional by-products (e.g., peas, lentils, or pinto beans, and their screenings) are increasingly utilized as pulse crop acreage expands in the Western US. These pulse by-products, although variable in nutrient composition, can provide a very cost-effective high crude protein (≳20%) alternative. Establishing communication with local elevators and pulse farmers for these and other by-products can help determine availability and price.

Getting the most out of your supplement option also depends on the efficiency of the animal in utilizing protein without excess protein being excreted. Rumen degradable protein (RDP) is easily broken down in the rumen and provides nitrogen to rumen microbes, whereas undegradable intake protein (UIP) or "by-pass protein" passes through the rumen unaltered by rumen microorganisms. This type of protein provides a more complete nutritional profile (amino acids) to the small intestine. Forages and small grains are typically higher in RDP, whereas by-product meals (e.g., DDGS, soybean meal, cotton seed meal) are higher in UIP. For example, 16 percent CP alfalfa is 4 percent UIP, but soybean meal and DDGS are 17.5 percent and 14.5 percent UIP, respectively

How much are you paying for protein?

You want to compare the cost per pound of crude protein (CP) 24 percent CP lick tub ($175 70 lb. tub) to a 20% percent CP alfalfa ($184.08/ton).

Step 1: Convert to Dry Matter Basis (90%)

Tub: 70 lb. x 0.9 = 63 lb. dry matter

Alfalfa: 2,000 lb. x 0.9 = 1,800 lb. dry matter

Step 2: Calculate Cost per Pound of Nutrient

Tub: 24% x 63 lb. = 15.12 lb. protein/tub

$175 ÷ 15.12 lb. protein = **$11.57/lb. protein**

Alfalfa: 20% x 1,800 lb. = 360 lb. protein/ton

$184.08 ÷ 360 lb. protein = **$0.51/lb. protein**

(NRC 2007). Sheep carrying multiple fetuses have a higher protein requirement throughout gestation and lactation (see Figure 1, page 4) and benefit more from UIP than a single-bearing ewe. Therefore, spending excess money on additional protein, which is typically more expensive, may be most advantageous with highly prolific breeds or in flocks with greater lambing percentages (>180%).

Testing of feed supplements is critical, to determine how much of a specific nutrient your supplement will provide, but also to calculate cost per pound of nutrient. Analyzing the cost per pound of nutrient can help ensure the most cost-effective purchasing decisions are made (Table 3, page 5). Uniformity of consumption, precision formulation, manipulating grazing distribution, and targeted delivery of vitamins and minerals are some of the merits of lick tub products. Notwithstanding these strengths, they are not always the most cost-effective option when evaluating on a cost per pound of nutrient (Figure 2, page 7). Take for example the comparison of a 24 percent crude protein lick tub fed at 1.5 ounces per day compared to 1 lb. of 18 percent alfalfa pellet. If target consumption of a 24 percent crude protein block is achieved at 1.5 oz. per head per day, that animal is consuming 0.023 lb. of protein per day. If the 70 lb. lick tub cost $175 this supplement costs approximately $2.50/lb. or $10.41 per pound of crude protein or $0.65 per ounce. One pound $250 per ton 18 percent crude protein alfalfa would provide 0.18 lb. of crude protein, at a cost of $0.12 per pound or $0.69 per pound of crude protein.

Fortifying supplements with vitamins and minerals is one advantage of purchasing a formulated “cake” or pellet. Generally, the mineral concentration of plants declines as the plant matures, but forbs and shrubs tend to have higher mineral concentration than grasses (Julian et al. 2020). Soil geochemistry may play a role in forage mineral content, but can still vary by location, plant species, and plant part (e.g., stem versus leaves). Forage sampling may provide a better estimation of mineral profile being consumed. A fortified pellet can be customized to meet nutrient requirements while increasing the likelihood of achieving target consumption over a loose or block mineral (Taylor et al. 2002; Stewart et al. 2021). It may also reduce input costs as commercial feed mills can fortify cake for an additional $10 to $25 per ton as opposed to a loose mineral which can cost $1,000 to $1,800 per ton (Stewart et al. 2021).

Supplement storage, delivery, and target consumption

Once nutrient shortfalls have been determined from the standing forage or hay and a supplement has been selected, we need to make sure we have the necessary resources to store the supplemental feedstuff, necessary equipment to deliver it to the sheep, and figure out if we can achieve the desired consumption per head per day.

Generally, bulk supplemental feedstuff is most economically purchased by the truck load (40,000 to 48,000 lb.). However, many sheep operations do not require this amount, nor do they have the storage capacity. In the case of pulse grain by-products and screenings, having the ability to store large amounts at a moment’s notice around harvest and milling can further lower the cost of obtaining these ingredients. Coordinating with other producers to share large bulk loads can also take advantage of the economy of scale. Storage options can vary from overhead bins, large totes, or a tarping system. Keeping by-products dry and free of mold is most important. Dry feed ingredients greater than 85 percent dry matter will not mold and therefore flow more easily in gravity-flow or auger systems. Nutritional variability across loads delivered is expected when feeding by-products and should be tested for nutritional composition with each load.

How will you get this supplement to your sheep? Can you access the supplemental feedstuff with loader, auger, gravity flow, or 5-gallon bucket? If feeding 100 lb. per day, then handling 5-gallon buckets may not be an issue but feeding 500 lb. might. Many range-sheep producers will feed on the ground when supplementing with a pelleted supplement or whole kernel grain, which will work fine when the ground is frozen, but will likely result in more wastage and feed contamination under muddy conditions. Low-cost bunks from repurposed pipes or other building material can reduce wastage.

A challenge of any limit fed supplementation program is ensuring that every animal is eating as close to the target supplement amount as possible. Breed and age differences can affect how uniformly a supplement is consumed. Fine-wool breeds show less aggressive feeding behavior at a trough than meat-type sheep breeds, and younger ewes (1 to 3 years) are at the trough more than ewes 4 to 6 years of age (Stewart et al. 2021). Making sure that there is adequate trough space when feeding supplements (6 to 8 inches according to Arnold and Maller [1974]) will reduce competition while feeding and ensure that ewes are eating the desired target amount rather than over- or under-consuming.

The added cost (labor, fuel, and time) of daily supplementation is often a concern. Alternated day feeding strategies with a high protein supplement can significantly decrease labor costs (Schauer et al. 2010). Supplementation with soybean meal when sheep are on low feed can be given every other day or up to every 10 days without reducing intake, nutrient digestibility, or performance (Schauer et al. 2010; McGuire et al. 2013).

Conclusions

Feed costs on Western US sheep operations represent the majority of variable costs year-to-year. Quality of forages varies throughout the year and does not always meet nutrient requirements during breeding, pregnancy, and lactation. Thus, producers rely on supplementation to meet nutritional shortfalls later in the season. Understanding the forage quality, quantity,

Table 5. Nutrient composition and cost per pound of protein and total digestible nutrients for supplementation options

	Supplement				
Nutrient and Cost	**Alfalfa (Hay Full Bloom)**	**Whole Corn**	**DDGS**	**Pea Screenings[1]**	**Soybean Meal**
Crude Protein (CP)	16%	9%	29%	25%	49%
Total Digestible Nutrients (TDN)	54%	88%	92%	86%	84%
Neutral Detergent Fiber (NDF)	52%	9%	42%	15%	62%
Acid Detergent Fiber (ADF)	40%	3%	21%	9%	46%
Calcium	1.20%	0.02%	0.15%	0.15%	0.55%
Phosphorus	0.23%	0.30%	0.78%	0.45%	0.17%
$/ton	$184.08	$137.50	$169.63	$210	$353
$/lb CP	$0.58	$0.76	$0.29	$0.42	$0.36
$/lb TDN	$0.17	$0.08	$0.09	$0.12	$0.21

Adapted from NRC 2007; USDA ERS 2021

[1]Cull pea cash prices reported from commercial mills and commodity brokers.

and species composition available to grazing sheep is an essential step in designing a precision supplementation program. In situations of low range production or adverse weather events substitution of the basal forage diet is required. Determining what supplemental feed to use should be based on whether protein or energy is required, and pricing on the specific cost per pound of nutrient. Implementing some of these considerations in forage-based sheep enterprises can optimize animal performance and save valuable input costs.

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* Internet addresses change and pages can disappear over time. If you find problems with any of the listed web sites in this publication, please contact Whit Stewart, UW Department of Animal Science, (304) 766-5374, whit.stewart@uwyo.edu

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