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Beef Cattle Nutrition Workbook

Animal Nutrient Requirements

Forage Value

Evaluating Feeds

Minerals and Vitamins

Ration Balancing

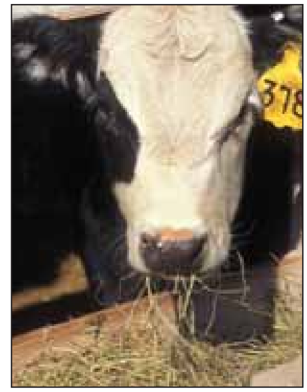
Supplements

Body Condition

Heifer Nutrition and Development

Oregon State UNIVERSITY | Extension Service

Contents



The *Beef Cattle Nutrition Workbook* is an interactive workbook to be used in conjunction with Oregon State University Extension Service Winter Nutrition Programs for beef producers.

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Preface

This *Beef Cattle Nutrition Workbook* is designed to be an interactive tool to help beef producers manage their herds. It contains information about beef cattle nutrient requirements, forage nutritive value, the importance of minerals and vitamins to cattle health and performance, balancing rations, economical supplementation strategies, heifer development, and the use of cow body condition score as a nutritional and reproductive management tool. Each chapter includes a worksheet to help you develop a ranch-specific plan for nutritional management of your beef herd. We hope you find this workbook helpful in the planning and execution of your nutritional programs.

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Animal Nutrient Requirements

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Shelby Filley and
Robert Pawelek

Different classes of animals have different requirements for total pounds of feed (intake), energy, protein, vitamins, and minerals. As demonstrated in Figures 1.1 and 1.2, the specific amounts needed depend on the animal's stage of production and the level of performance desired by the livestock manager. Requirements also may vary depending on previous diet. For example, when an animal has been on a limited diet and then is fed a more nutritious diet, the diet is utilized more efficiently in a compensatory manner. Frame score (structural size) also influences requirements (see references, page 2).

Water is another crucial part of a livestock nutrition program. Livestock should always have access to adequate quantities of good-quality, clean water. Lack of water leads to decreased feed intake, lower production, and reduced revenues. Water requirements for a cow–calf pair range from 12 to 20 gallons per day. Yearling cattle require 6 to 14 gallons per day.

Certain metals and contaminants are detrimental to livestock if present in water at significant levels. Test water to make sure the water is free from harmful materials (see references, page 2).

Initial steps to evaluating livestock rations include: (1) describing the animal, and (2) determining the animal's nutrient requirements. Nutrient

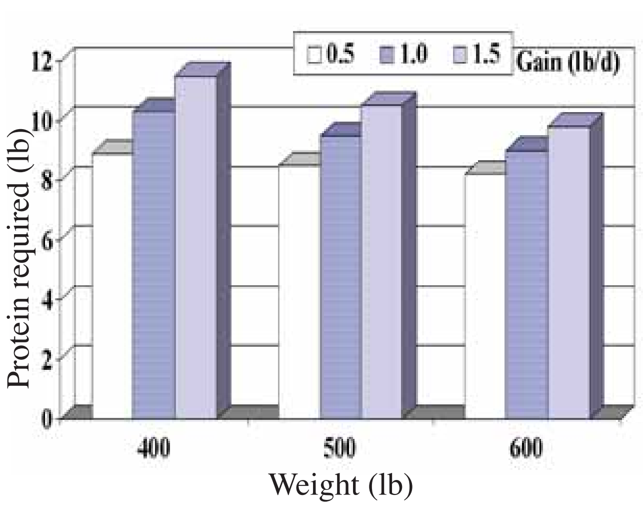

Figure 1.1—Protein requirements of medium-framed steers at various weights and rates of gain.

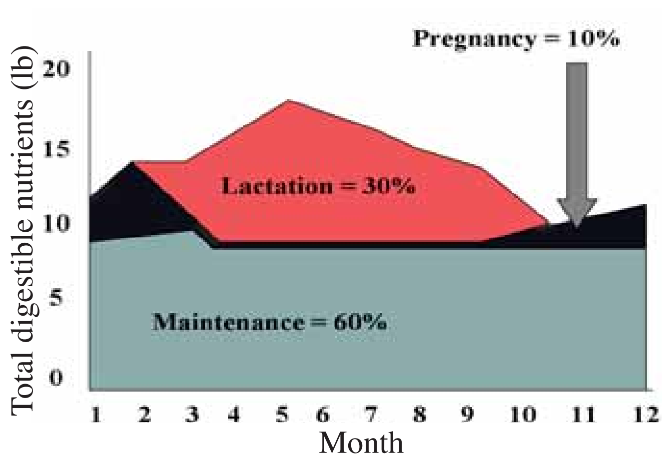

Figure 1.2—Example of annual energy inputs for a spring-calving cow. Source: Zollinger, B. and D. Hansen. 2003. *OSU Calving School Handbook*, Animal Sciences publication 110. http://oregonstate.edu/dept/animal-sciences/cschhand.pdf

requirements for growing and finishing cattle (Table 1.1) and for breeding cattle (Table 1.2) are included on pages 5–17.

A word of caution when using these tables: environmental factors such as mud, snow, cold, etc. increase nutrient requirements, particularly for energy. For instance, the critical temperature for most wintering cows in eastern Oregon is around 30°F. When wind chill drops below 30°F, the energy requirement increases. For each 1°F drop in wind chill, the energy requirement increases by 1 percent. If the wind chill is 0°F, the energy requirement required to maintain the cow increases by 30 percent. Also, cows in poor body condition take more energy for maintenance than cows in good body condition (see Chapter 7).

To begin an evaluation of your livestock-feeding program, fill in the following worksheets using the appropriate tables.

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Worksheet 1.1
Nutrient Requirements for Growing and Finishing Cattle

1. Animal description

Frame and sex ____________________

Growth characteristics (compensating or not) ____________________

Animal weight ____________________

Daily gain desired ____________________
Average daily gain = (final weight – current weight) ÷ days to gain

Climatic and lot conditions (temperature, precipitation, mud, snow, etc.) ____________________

____

____

2. Nutrient requirements (per day)—see Table 1.1

Expected dry matter intake (DMI): pounds ____________________

Protein: % in diet ____________ pounds ____________________

Energy, total digestible nutrients (TDN): % in diet ____________ pounds ____________

Calcium (% Ca) ____________________

Phosphorus (% P) ____________________

Worksheet 1.2
Nutrient Requirements for Breeding Cattle

1. Animal description

Sex and age ______________________________

Stage of pregnancy/lactation ______________________________

Milking ability (average = 10 lb/day; superior = 20 lb/day) ______________________________

Animal weight ______________________________

Daily gain desired ______________________________
Average daily gain = (final weight – current weight) ÷ days to gain

2. Nutrient requirements (per day)—see Table 1.2

Expected dry matter intake (DMI): pounds ______________________________

Protein: % in diet ______________ pounds ______________

Energy, total digestible nutrients (TDN): % in diet __________ pounds ______________

Calcium (% Ca) ______________________________

Phosphorus (% P) ______________________________

Table 1.1. Nutrient requirements for growing and finishing cattle (nutrient concentration in diet dry matter)[a]

Weight (lb)	Daily gain (lb/day)	DM intake (lb)	Protein (%)	Protein (lb)	TDN (%)	TDN (lb)	Ca (%)	P (%)
Medium-frame steer calves								
300	0.5	7.8	9.6	0.75	54.0	4.2	0.31	0.20
	1.0	8.4	11.4	0.95	58.5	4.9	0.45	0.24
	1.5	8.7	13.2	1.14	63.0	5.5	0.58	0.28
	2.0	8.9	14.8	1.32	67.5	6.0	0.72	0.32
	2.5	8.9	16.7	1.48	73.5	6.5	0.87	0.37
	3.0	8.0	19.9	1.60	85.0	6.8	1.13	0.47
400	0.5	9.7	8.9	0.87	54.0	5.2	0.27	0.18
	1.0	10.4	10.3	1.06	58.5	6.1	0.38	0.21
	1.5	10.8	11.5	1.24	63.0	6.8	0.47	0.25
	2.0	11.0	12.7	1.41	67.5	7.4	0.56	0.26
	2.5	11.0	14.2	1.56	73.5	8.1	0.68	0.30
	3.0	10.0	16.6	1.65	85.0	8.5	0.86	0.37
500	0.5	11.5	8.5	0.98	54.0	6.2	0.25	0.17
	1.0	12.3	9.5	1.16	58.5	7.2	0.32	0.20
	1.5	12.8	10.5	1.33	63.0	8.1	0.40	0.22
	2.0	13.1	11.4	1.49	67.5	8.8	0.47	0.24
	2.5	13.0	12.5	1.63	73.5	9.6	0.56	0.27
	3.0	11.8	14.4	1.69	85.0	10.0	0.69	0.32
600	0.5	13.2	8.2	1.08	54.0	7.1	0.23	0.18
	1.0	14.1	9.0	1.26	58.5	8.3	0.28	0.19
	1.5	14.7	9.8	1.42	63.0	9.3	0.35	0.21
	2.0	15.0	10.5	1.57	67.5	10.1	0.40	0.22
	2.5	14.9	11.4	1.69	73.5	11.0	0.46	0.24
	3.0	13.5	12.9	1.73	85.0	11.5	0.57	0.29
700	0.5	14.8	7.9	1.18	54.0	8.0	0.22	0.18
	1.0	15.8	8.6	1.35	58.5	9.2	0.27	0.18
	1.5	16.5	9.2	1.50	63.0	10.4	0.31	0.20
	2.0	16.8	9.8	1.65	67.5	11.3	0.34	0.21
	2.5	16.7	10.5	1.75	73.5	12.3	0.40	0.22
	3.0	15.2	11.7	1.77	85.0	12.9	0.49	0.26

[a]DM = dry matter; TDN = total digestible nutrients (energy); Ca = calcium; P = phosphorus

Table 1.1. Nutrient requirements for growing and finishing cattle (nutrient concentration in diet dry matter)[a]

Weight (lb)	Daily gain (lb/day)	DM intake (lb)	Protein (%)	Protein (lb)	TDN (%)	TDN (lb)	Ca (%)	P (%)
Medium-frame steer calves (continued)								
800	0.5	16.4	7.7	1.27	54.0	8.9	0.22	0.17
	1.0	17.5	8.3	1.44	58.5	10.2	0.24	0.19
	1.5	18.2	8.8	1.58	63.0	11.5	0.28	0.19
	2.0	18.6	9.2	1.72	67.5	12.6	0.31	0.20
	2.5	18.5	9.8	1.81	73.5	13.6	0.35	0.21
	3.0	16.8	10.8	1.81	85.0	14.3	0.42	0.25
900	0.5	17.9	7.6	1.36	54.0	9.7	0.21	0.18
	1.0	19.1	8.0	1.52	58.5	11.2	0.23	0.18
	1.5	19.9	8.4	1.66	63.0	12.5	0.25	0.19
	2.0	20.3	8.8	1.79	67.5	13.7	0.28	0.20
	2.5	20.2	9.3	1.87	73.5	14.8	0.31	0.20
	3.0	18.3	10.1	1.85	85.0	15.6	0.37	0.23
1,000	0.5	19.3	7.5	1.45	54.0	10.4	0.21	0.18
	1.0	20.7	7.8	1.60	58.5	12.1	0.21	0.18
	1.5	21.5	8.1	1.74	63.0	13.5	0.24	0.18
	2.0	22.0	8.4	1.85	67.5	14.9	0.25	0.19
	2.5	21.9	8.8	1.92	73.5	16.1	0.27	0.19
	3.0	19.8	9.5	1.88	85.0	16.8	0.32	0.22
Large-frame steer calves and compensating medium-frame yearling steers								
300	0.5	8.2	9.5	0.77	52.5	4.3	0.30	0.19
	1.0	8.7	11.3	0.99	56.0	4.9	0.46	0.23
	1.5	9.1	12.9	1.19	59.5	5.4	0.58	0.27
	2.0	9.4	14.6	1.37	63.5	6.0	0.70	0.30
	2.5	9.6	16.3	1.55	67.5	6.5	0.85	0.34
	3.0	9.6	18.0	1.73	72.0	6.9	0.99	0.39
	3.5	9.3	20.3	1.88	78.5	7.3	1.16	0.45
400	0.5	10.1	8.9	0.89	52.5	5.3	0.26	0.17
	1.0	10.8	10.2	1.10	56.0	6.0	0.37	0.20
	1.5	11.3	11.4	1.30	59.5	6.7	0.47	0.23
	2.0	11.7	12.7	1.47	63.5	7.4	0.57	0.26
	2.5	11.9	13.9	1.64	67.5	8.0	0.65	0.30
	3.0	11.9	15.2	1.81	72.0	8.6	0.76	0.33
	3.5	11.5	16.9	1.94	78.5	9.0	0.90	0.36

Table 1.1. Nutrient requirements for growing and finishing cattle (nutrient concentration in diet dry matter)[a]

Weight (lb)	Daily gain (lb/day)	DM intake (lb)	Protein (%)	Protein (lb)	TDN (%)	TDN (lb)	Ca (%)	P (%)
Large-frame steer calves and compensating medium-frame yearling steers (continued)								
500	0.5	12.0	8.5	1.00	52.5	6.3	0.24	0.17
	1.0	12.8	9.5	1.21	56.0	7.2	0.33	0.19
	1.5	13.4	10.4	1.40	59.5	8.0	0.39	0.21
	2.0	13.8	11.4	1.57	63.5	8.8	0.46	0.24
	2.5	14.0	12.4	1.73	67.5	9.5	0.55	0.25
	3.0	14.0	13.4	1.88	72.0	10.1	0.63	0.28
	3.5	13.6	14.7	2.00	78.5	10.7	0.73	0.32
600	0.5	13.8	8.2	1.11	52.5	7.2	0.22	0.18
	1.0	14.6	9.0	1.31	56.0	8.2	0.29	0.18
	1.5	15.3	9.7	1.50	59.5	9.1	0.35	0.20
	2.0	15.8	10.5	1.66	63.5	10.0	0.40	0.22
	2.5	16.1	11.3	1.81	67.5	10.9	0.47	0.23
	3.0	16.1	12.1	1.95	72.0	11.6	0.52	0.26
	3.5	15.6	13.2	2.05	78.5	12.2	0.61	0.28
700	0.5	15.4	7.9	1.21	52.5	8.1	0.21	0.17
	1.0	16.4	8.6	1.41	56.0	9.2	0.27	0.19
	1.5	17.2	9.2	1.59	59.5	10.2	0.31	0.19
	2.0	17.8	9.8	1.74	63.5	11.3	0.36	0.21
	2.5	18.0	10.5	1.88	67.5	12.2	0.40	0.22
	3.0	18.0	11.1	2.01	72.0	13.0	0.45	0.23
	3.5	17.5	12.0	2.10	78.5	13.7	0.52	0.26
800	0.5	17.1	7.7	1.31	52.5	8.9	0.21	0.18
	1.0	18.2	8.3	1.51	56.0	10.2	0.24	0.18
	1.5	19.0	8.8	1.68	59.5	11.3	0.28	0.19
	2.0	19.6	9.3	1.82	63.5	12.4	0.32	0.20
	2.5	19.9	9.8	1.96	67.5	13.4	0.35	0.21
	3.0	19.9	10.4	2.07	72.0	14.3	0.40	0.22
	3.5	19.3	11.1	2.15	78.5	15.2	0.45	0.24
900	0.5	18.6	7.6	1.40	52.5	9.8	0.20	0.18
	1.0	19.8	8.0	1.60	56.0	11.2	0.23	0.18
	1.5	20.8	8.5	1.77	59.5	12.4	0.27	0.18
	2.0	21.4	8.9	1.90	63.5	13.6	0.29	0.20
	2.5	21.8	9.3	2.03	67.5	14.7	0.31	0.20
	3.0	21.7	9.8	2.13	72.0	15.6	0.36	0.21
	3.5	21.1	10.4	2.19	78.5	16.6	0.40	0.23

Table 1.1. Nutrient requirements for growing and finishing cattle (nutrient concentration in diet dry matter)[a]

Weight (lb)	Daily gain (lb/day)	DM intake (lb)	Protein (%)	Protein (lb)	TDN (%)	TDN (lb)	Ca (%)	P (%)
Large-frame steer calves and compensating medium-frame yearling steers (continued)								
1,000	0.5	20.2	7.5	1.49	52.5	10.6	0.20	0.17
	1.0	21.5	7.8	1.69	56.0	12.0	0.23	0.17
	1.5	22.5	8.2	1.85	59.5	13.4	0.25	0.18
	2.0	23.2	8.6	1.98	63.5	14.7	0.27	0.18
	2.5	23.6	8.9	2.09	67.5	15.9	0.29	0.19
	3.0	23.6	9.3	2.19	72.0	17.0	0.32	0.20
	3.5	22.8	9.8	2.24	78.5	17.9	0.35	0.21
1,100	0.5	21.7	7.4	1.58	52.5	11.4	0.19	0.18
	1.0	23.1	7.7	1.77	56.0	12.9	0.21	0.18
	1.5	24.1	8.0	1.93	59.5	14.3	0.23	0.18
	2.0	24.9	8.3	2.05	63.5	15.8	0.25	0.18
	2.5	25.3	8.5	2.16	67.5	17.1	0.26	0.18
	3.0	25.3	8.9	2.25	72.0	18.2	0.29	0.19
	3.5	24.5	9.3	2.28	78.5	19.2	0.32	0.21
Medium-frame bulls								
300	0.5	7.8	9.7	0.76	53.5	4.2	0.31	0.20
	1.0	8.3	11.6	0.96	57.5	4.8	0.48	0.24
	1.5	8.6	13.4	1.15	61.5	5.3	0.62	0.28
	2.0	8.8	15.2	1.34	65.5	5.8	0.75	0.33
	2.5	8.9	17.0	1.52	70.0	6.2	0.92	0.37
	3.0	8.7	19.3	1.68	76.5	6.7	1.09	0.43
400	0.5	9.6	9.0	0.87	53.5	5.1	0.28	0.18
	1.0	10.3	10.4	1.07	57.5	5.9	0.39	0.21
	1.5	10.7	11.8	1.26	61.5	6.6	0.49	0.25
	2.0	11.0	13.1	1.44	65.5	7.2	0.60	0.28
	2.5	11.1	14.4	1.60	70.0	7.8	0.70	0.32
	3.0	10.8	16.1	1.74	76.5	8.3	0.84	0.37
500	0.5	11.4	8.6	0.98	53.5	6.1	0.25	0.17
	1.0	12.1	9.7	1.17	57.5	7.0	0.35	0.20
	1.5	12.7	10.7	1.35	61.5	7.8	0.42	0.23
	2.0	13.0	11.7	1.52	65.5	8.5	0.49	0.25
	2.5	13.1	12.8	1.68	70.0	9.2	0.59	0.27
	3.0	12.8	14.1	1.81	76.5	9.8	0.69	0.31

Table 1.1. Nutrient requirements for growing and finishing cattle (nutrient concentration in diet dry matter)[a]

Weight (lb)	Daily gain (lb/day)	DM intake (lb)	Protein (%)	Protein (lb)	TDN (%)	TDN (lb)	Ca (%)	P (%)
Medium-frame bulls (continued)								
600	0.5	13.1	8.3	1.08	53.5	7.0	0.24	0.19
	1.0	13.9	9.2	1.27	57.5	8.0	0.30	0.19
	1.5	14.5	10.0	1.44	61.5	8.9	0.36	0.21
	2.0	14.9	10.8	1.61	65.5	9.8	0.43	0.24
	2.5	15.0	11.6	1.75	70.0	10.5	0.50	0.25
	3.0	14.7	12.7	1.86	76.5	11.2	0.57	0.29
700	0.5	14.7	8.0	1.18	53.5	7.9	0.23	0.18
	1.0	15.6	8.8	1.37	57.5	9.0	0.28	0.20
	1.5	16.3	9.4	1.53	61.5	10.0	0.32	0.20
	2.0	16.7	10.1	1.69	65.5	10.9	0.38	0.22
	2.5	16.8	10.8	1.82	70.0	11.8	0.43	0.24
	3.0	16.5	11.7	1.92	76.5	12.6	0.49	0.25
800	0.5	16.2	7.8	1.27	53.5	8.7	0.22	0.19
	1.0	17.3	8.4	1.45	57.5	9.9	0.25	0.19
	1.5	18.0	9.0	1.61	61.5	11.1	0.29	0.20
	2.0	18.5	9.5	1.76	65.5	12.1	0.33	0.21
	2.5	18.6	10.1	1.89	70.0	13.0	0.38	0.23
	3.0	18.2	10.8	1.97	76.5	13.9	0.44	0.24
900	0.5	17.7	7.7	1.36	53.5	9.5	0.21	0.19
	1.0	18.9	8.2	1.54	57.5	10.9	0.25	0.19
	1.5	19.7	8.6	1.69	61.5	12.1	0.28	0.19
	2.0	20.2	9.1	1.83	65.5	13.2	0.31	0.21
	2.5	20.3	9.6	1.95	70.0	14.2	0.34	0.22
	3.0	19.9	10.2	2.02	76.5	15.2	0.39	0.23
1,000	0.5	19.2	7.5	1.45	53.5	10.3	0.21	0.18
	1.0	20.4	8.0	1.62	57.5	11.7	0.24	0.18
	1.5	21.3	8.4	1.77	61.5	13.1	0.26	0.19
	2.0	21.8	8.7	1.90	65.5	14.3	0.28	0.19
	2.5	22.0	9.1	2.01	70.0	15.4	0.31	0.20
	3.0	21.5	9.6	2.07	76.5	16.4	0.35	0.22
1,100	0.5	20.6	7.4	1.54	53.5	11.0	0.20	0.19
	1.0	21.9	7.8	1.70	57.5	12.6	0.22	0.19
	1.5	22.9	8.1	1.85	61.5	14.1	0.24	0.19
	2.0	23.4	8.4	1.97	65.5	15.3	0.26	0.19
	2.5	23.6	8.7	2.07	70.0	16.5	0.28	0.20
	3.0	23.1	9.2	2.11	76.5	17.7	0.32	0.21

Table 1.1. Nutrient requirements for growing and finishing cattle (nutrient concentration in diet dry matter)[a]

Weight (lb)	Daily gain (lb/day)	DM intake (lb)	Protein (%)	Protein (lb)	TDN (%)	TDN (lb)	Ca (%)	P (%)
Large-frame bull calves and compensating large-frame yearling steers								
300	0.5	7.9	9.7	0.77	52.5	4.1	0.31	0.20
	1.0	8.4	11.7	0.98	56.0	4.7	0.47	0.24
	1.5	8.8	13.5	1.18	59.5	5.2	0.63	0.28
	2.5	9.2	17.0	1.56	66.5	6.1	0.91	0.36
	3.0	9.2	18.8	1.74	70.5	6.5	1.08	0.43
	3.5	9.1	20.9	1.91	75.5	6.9	1.24	0.48
	4.0	8.2	24.7	2.04	86.0	7.1	1.53	0.59
400	0.5	9.8	9.0	0.89	52.5	5.1	0.27	0.18
	1.0	10.4	10.5	1.09	56.0	5.8	0.40	0.21
	1.5	10.9	11.9	1.29	59.5	6.5	0.51	0.24
	2.0	11.2	13.1	1.48	62.5	7.0	0.61	0.28
	2.5	11.4	14.5	1.65	66.5	7.6	0.72	0.31
	3.0	11.5	15.9	1.82	70.5	8.1	0.82	0.35
	3.5	11.3	17.5	1.98	75.5	8.5	0.96	0.39
	4.0	10.2	20.3	2.08	86.0	8.8	1.19	0.48
500	0.5	11.6	8.6	1.00	52.5	6.1	0.25	0.19
	1.0	12.3	9.8	1.20	56.0	6.9	0.36	0.21
	1.5	12.9	10.9	1.39	59.5	7.7	0.43	0.22
	2.0	13.2	11.8	1.58	62.5	8.3	0.52	0.25
	2.5	13.5	12.9	1.74	66.5	9.0	0.59	0.28
	3.0	13.6	14.0	1.90	70.5	9.6	0.68	0.31
	3.5	13.4	15.3	2.05	75.5	10.1	0.77	0.35
	4.0	12.0	17.5	2.13	86.0	10.3	0.97	0.40
600	0.5	13.3	8.3	1.10	52.5	7.0	0.23	0.18
	1.0	14.1	9.2	1.30	56.0	7.9	0.31	0.20
	1.5	14.8	10.1	1.48	59.5	8.8	0.37	0.21
	2.0	15.2	10.9	1.67	62.5	9.5	0.44	0.23
	2.5	15.5	11.8	1.82	66.5	10.3	0.51	0.26
	3.0	15.5	12.7	1.97	70.5	10.9	0.58	0.27
	3.5	15.3	13.7	2.11	75.5	11.6	0.66	0.30
	4.0	13.8	15.6	2.16	86.0	11.9	0.81	0.37

Table 1.1. Nutrient requirements for growing and finishing cattle (nutrient concentration in diet dry matter)[a]

Weight (lb)	Daily gain (lb/day)	DM intake (lb)	Protein (%)	Protein (lb)	TDN (%)	TDN (lb)	Ca (%)	P (%)
Large-frame bull calves and compensating large-frame yearling steers (continued)								
700	0.5	14.9	8.0	1.20	52.5	7.8	0.22	0.18
	1.0	15.9	8.8	1.40	56.0	8.9	0.29	0.19
	1.5	16.6	9.6	1.57	59.5	9.9	0.35	0.21
	2.0	17.0	10.2	1.75	62.5	10.6	0.39	0.22
	2.5	17.4	11.0	1.90	66.5	11.6	0.44	0.24
	3.0	17.5	11.7	2.04	70,5	12.3	0.50	0.25
	3.5	17.2	12.5	2.16	75.5	13.0	0.56	0.25
	4.0	15.5	14.1	2.20	86.0	13.3	0.70	0.33
800	0.5	16.5	7.9	1.30	52.5	8.7	0.21	0.19
	1.0	17.5	8.5	1.49	56.0	9.8	0.26	0.19
	1.5	18.3	9.1	1.66	59.5	10.9	0.31	0.20
	2.0	18.8	9.7	1.84	62.5	11.8	0.35	0.21
	2.5	19.2	10.3	1.97	66.5	12.8	0.40	0.23
	3.0	19.3	10.9	2.11	70,5	13.6	0.45	0.24
	3.5	19.0	11.6	2.22	75.5	14.3	0.50	0.26
	4.0	17.1	13.0	2.24	86.0	14.7	0.61	0.31
900	0.5	18.0	7.7	1.39	52.5	9.5	0.22	0.18
	1.0	19.2	8.3	1.58	56.0	10.8	0.25	0.18
	1.5	20.0	8.8	1.74	59.5	11.9	0.29	0.20
	2.0	20.6	9.2	1.92	62.5	12.9	0.32	0.20
	2.5	21.0	9.8	2.04	66.5	14.0	0.36	0.21
	3.0	21.1	10.3	2.17	70,5	14.9	0.40	0.23
	3.5	20.8	10.9	2.27	75.5	15.7	0.45	0.24
	4.0	18.7	12.1	2.27	86.0	16.1	0.53	0.28
1,000	0.5	19.5	7.6	1.48	52.5	10.2	0.21	0.18
	1.0	20.7	8.1	1.66	56.0	11.6	0.25	0.19
	1.5	21.7	8.5	1.83	59.5	12.9	0.27	0.19
	2.0	22.3	8.9	1.99	62.5	13.9	0.30	0.20
	2.5	22.7	9.3	2.11	66.5	15.1	0.33	0.20
	3.0	22.8	9.7	2.23	70.5	16.1	0.36	0.21
	3.5	22.5	10.3	2.32	75.5	17.0	0.40	0.24
	4.0	20.2	11.3	2.30	86.0	17.4	0.48	0.27

Table 1.1. Nutrient requirements for growing and finishing cattle (nutrient concentration in diet dry matter)[a]

Weight (lb)	Daily gain (lb/day)	DM intake (lb)	Protein (%)	Protein (lb)	TDN (%)	TDN (lb)	Ca (%)	P (%)
Large-frame bull calves and compensating large-frame yearling steers (continued)								
1,100	0.5	20.9	7.5	1.57	52.5	11.0	0.21	0.19
	1.0	22.3	7.9	1.75	56.0	12.5	0.23	0.19
	1.5	23.3	8.3	1.91	59.5	13.9	0.26	0.19
	2.0	23.9	8.6	2.07	62.5	14.9	0.28	0.19
	2.5	24.2	9.0	2.18	66.5	16.1	0.30	0.20
	3.0	24.5	9.3	2.29	70.5	17.3	0.32	0.21
	3.5	24.1	9.8	2.37	75.5	18.2	0.36	0.22
	4.0	21.7	10.7	2.33	86.0	18.7	0.43	0.25
Medium-frame heifer calves								
300	0.5	7.5	9.6	0.73	56.0	4.2	0.29	0.21
	1.0	8.0	11.4	0.91	62.0	5.0	0.44	0.22
	1.5	8.2	13.1	1.08	68.5	5.6	0.59	0.27
	2.0	8.0	15.1	1.22	77.0	6.2	0.74	0.33
400	0.5	9.3	8.9	0.84	56.0	5.2	0.26	0.19
	1.0	9.9	10.2	1.01	62.0	6.1	0.36	0.20
	1.5	10.2	11.4	1.17	68.5	7.0	0.45	0.24
	2.0	10.0	12.9	1.29	77.0	7.7	0.57	0.29
500	0.5	11.0	8.5	0.94	56.0	6.2	0.24	0.18
	1.0	11.8	9.4	1.11	62.0	7.3	0.30	0.21
	1.5	12.1	10.3	1.25	68.5	8.4	0.38	0.22
	2.0	11.8	11.4	1.35	77.0	9.1	0.45	0.24
600	0.5	12.6	8.1	1.04	56.0	7.1	0.23	0.18
	1.0	13.5	8.8	1.19	62.0	8.4	0.28	0.20
	1.5	13.8	9.5	1.32	68.5	9.5	0.32	0.21
	2.0	13.5	10.4	1.41	77.0	10.4	0.38	0.23
700	0.5	14.1	7.9	1.13	56.0	8.0	0.22	0.19
	1.0	15.1	8.4	1.28	62.0	9.4	0.25	0.19
	1.5	15.5	9.0	1.39	68.5	10.6	0.28	0.20
	2.0	15.2	9.6	1.46	77.0	11.7	0.32	0.22
800	0.5	15.6	7.7	1.22	56.0	8.7	0.21	0.18
	1.0	16.7	8.1	1.36	62.0	10.4	0.22	0.18
	1.5	17.2	8.5	1.46	68.5	11.8	0.24	0.19
	2.0	16.8	9.0	1.51	77.0	12.9	0.28	0.20

Table 1.1. Nutrient requirements for growing and finishing cattle (nutrient concentration in diet dry matter)[a]

Weight (lb)	Daily gain (lb/day)	DM intake (lb)	Protein (%)	Protein (lb)	TDN (%)	TDN (lb)	Ca (%)	P (%)
Medium-frame heifer calves (continued)								
900	0.5	17.1	7.5	1.31	56.0	9.6	0.21	0.18
	1.0	18.3	7.8	1.44	62.0	11.3	0.22	0.18
	1.5	18.8	8.1	1.53	68.5	12.9	0.22	0.19
	2.0	18.3	8.5	1.56	77.0	14.1	0.25	0.19
1,000	0.5	18.5	7.4	1.39	56.0	10.4	0.20	0.19
	1.0	19.8	7.6	1.51	62.0	12.3	0.20	0.18
	1.5	20.3	7.8	1.59	68.5	13.9	0.21	0.18
	2.0	19.8	8.1	1.61	77.0	15.2	0.22	0.19
Large-frame heifer calves and compensating medium-frame yearling heifers								
300	0.5	7.8	9.5	0.76	54.0	4.2	0.31	0.20
	1.0	8.4	11.3	0.95	59.0	5.0	0.45	0.24
	1.5	8.8	13.0	1.13	64.0	5.6	0.58	0.25
	2.0	8.9	14.6	1.30	69.5	6.2	0.69	0.30
	2.5	8.7	16.7	1.45	77.0	7.0	0.86	0.35
400	0.5	9.7	8.9	0.87	54.0	5.2	0.27	0.18
	1.0	10.5	10.1	1.06	59.0	6.2	0.36	0.21
	1.5	10.9	11.3	1.23	64.0	7.0	0.45	0.22
	2.0	11.1	12.6	1.38	69.5	7.7	0.54	0.26
	2.5	10.8	14.1	1.51	77.0	8.3	0.65	0.31
500	0.5	11.5	8.4	0.98	54.0	6.1	0.23	0.17
	1.0	12.4	9.4	1.16	59.0	7.3	0.30	0.20
	1.5	12.9	10.3	1.32	64.0	8.3	0.38	0.20
	2.0	13.1	11.2	1.46	69.5	9.1	0.44	0.24
	2.5	12.8	12.4	1.57	77.0	10.0	0.53	0.26
600	0.5	13.2	8.1	1.08	54.0	7.1	0.22	0.18
	1.0	14.1	8.9	1.25	59.0	8.3	0.28	0.19
	1.5	14.8	9.6	1.41	64.0	9.5	0.33	0.19
	2.0	15.0	10.3	1.54	69.5	10.4	0.38	0.22
	2.5	14.6	11.2	1.63	77.0	11.2	0.44	0.24
700	0.5	14.8	7.9	1.18	54.0	8.0	0.21	0.18
	1.0	15.9	8.5	1.34	59.0	9.4	0.25	0.18
	1.5	16.6	9.0	1.49	64.0	10.6	0.29	0.19
	2.0	16.8	9.6	1.61	69.5	11.7	0.33	0.20
	2.5	16.4	10.3	1.68	77.0	12.6	0.38	0.22

Table 1.1. Nutrient requirements for growing and finishing cattle (nutrient concentration in diet dry matter)[a]

Weight (lb)	Daily gain (lb/day)	DM intake (lb)	Protein (%)	Protein (lb)	TDN (%)	TDN (lb)	Ca (%)	P (%)
Large-frame heifer calves and compensating medium-frame yearling heifers (continued)								
800	0.5	16.4	7.7	1.27	54.0	8.9	0.20	0.17
	1.0	17.6	8.2	1.43	59.0	10.4	0.24	0.18
	1.5	18.3	8.6	1.57	64.0	11.7	0.25	0.18
	2.0	18.6	9.0	1.67	69.5	12.9	0.28	0.19
	2.5	18.1	9.6	1.74	77.0	13.9	0.33	0.21
900	0.5	17.8	7.5	1.36	54.0	9.6	0.20	0.18
	1.0	19.2	7.9	1.52	59.0	11.3	0.22	0.18
	1.5	20.0	8.2	1.64	64.0	12.8	0.23	0.18
	2.0	20.3	8.6	1.74	69.5	14.1	0.26	0.18
	2.5	19.8	9.0	1.78	77.0	15.2	0.29	0.20
1,000	0.5	19.3	7.4	1.45	54.0	10.4	0.19	0.18
	1.0	20.8	7.7	1.60	59.0	12.3	0.21	0.18
	1.5	21.7	8.0	1.71	64.0	13.9	0.21	0.18
	2.0	22.0	8.2	1.80	69.5	15.3	0.23	0.18
	2.5	21.5	8.6	1.83	77.0	16.6	0.25	0.18
1,100	0.5	20.8	7.3	1.54	54.0	11.2	0.19	0.18
	1.0	22.3	7.5	1.68	59.0	13.2	0.20	0.18
	1.5	23.3	7.7	1.78	64.0	14.9	0.20	0.18
	2.0	23.6	7.9	1.86	69.5	16.4	0.21	0.18
	2.5	23.1	8.2	1.88	77.0	17.8	0.22	0.18

Source: Adapted from National Research Council. 1984. *Nutrient Requirements of Beef Cattle*. National Academies Press, Washington, DC.

Table 1.2. Nutrients requirements of breeding beef cattle (nutrient concentration in diet dry matter).[a]

Weight (lb)	Daily gain (lb/day)	DM intake (lb)	Protein (%)	Protein (lb)	TDN (%)	TDN (lb)	Ca (%)	P (%)
Pregnant yearling heifers—last third of pregnancy								
700	0.9	15.3	8.4	1.3	55.4	8.5	0.27	0.20
	1.4	15.8	9.0	1.4	60.3	9.6	0.33	0.21
	1.9	15.8	9.8	1.5	67.0	10.6	0.33	0.21
750	0.9	16.1	8.3	1.3	55.1	8.9	0.27	0.19
	1.4	16.6	8.9	1.5	59.9	10.0	0.32	0.21
	1.9	16.6	9.5	1.6	66.5	11.1	0.37	0.23
800	0.9	16.8	8.2	1.4	54.8	9.2	0.28	0.20
	1.4	17.4	8.8	1.5	59.6	10.4	0.33	0.21
	1.9	17.5	9.3	1.6	66.1	11.6	0.35	0.21
850	0.9	17.6	8.2	1.4	54.5	9.6	0.26	0.20
	1.4	18.2	8.6	1.6	59.3	10.8	0.30	0.21
	1.9	18.3	9.1	1.7	65.7	12.1	0.34	0.22
900	0.9	18.3	8.1	1.5	54.3	9.9	0.26	0.20
	1.4	19.0	8.5	1.6	59.1	11.3	0.30	0.21
	1.9	19.2	9.0	1.7	65.4	12.5	0.32	0.21
950	0.9	19.0	8.0	1.5	54.1	10.3	0.27	0.20
	1.4	19.8	8.4	1.7	58.9	11.7	0.29	0.21
	1.9	20.0	8.8	1.8	65.1	13.0	0.32	0.21
Dry pregnant mature cows—middle third of pregnancy								
800	0.0	15.3	7.1	1.1	48.8	7.5	0.17	0.17
900	0.0	16.7	7.0	1.2	48.8	8.2	0.18	0.18
1,000	0.0	18.1	7.0	1.3	48.8	8.8	0.18	0.18
1,100	0.0	19.5	7.0	1.4	48.8	9.5	0.19	0.19
1,200	0.0	20.8	6.9	1.4	48.8	10.1	0.19	0.19
1,300	0.0	22.0	6.9	1.5	48.8	10.8	0.20	0.20
1,400	0.0	23.3	6.9	1.6	48.8	11.4	0.20	0.20
Dry pregnant mature cows—last third of pregnancy								
800	0.9	16.8	8.2	1.4	54.5	9.2	0.26	0.20
900	0.9	18.2	8.0	1.5	54.0	9.8	0.27	0.21
1,000	0.9	19.6	7.9	1.6	53.6	10.5	0.26	0.20
1,100	0.9	21.0	7.8	1.6	53.2	11.2	0.26	0.21
1,200	0.9	22.3	7.8	1.7	52.9	11.8	0.26	0.21
1,300	0.9	23.6	7.7	1.8	52.7	12.5	0.26	0.21
1,400	0.9	24.9	7.6	1.9	52.5	13.1	0.26	0.21

[a]DM = dry matter; TDN = total digestible nutrients (energy); Ca = calcium; P = phosphorus

Table 1.2. Nutrients requirements of breeding beef cattle (nutrient concentration in diet dry matter).[a]

Weight (lb)	Daily gain (lb/day)	DM intake (lb)	Protein (%)	Protein (lb)	TDN (%)	TDN (lb)	Ca (%)	P (%)
Two-year-old heifers nursing calves—first 3 to 4 months postpartum—10 lb milk/day								
700	0.5	15.9	11.3	1.8	65.1	10.3	0.36	0.24
750	0.5	16.7	11.0	1.8	64.4	10.8	0.34	0.24
800	0.5	17.6	10.8	1.9	63.8	11.2	0.34	0.24
850	0.5	18.4	10.6	1.9	63.2	11.6	0.33	0.23
900	0.5	19.2	10.4	2.0	62.7	12.0	0.33	0.23
950	0.5	20.0	10.2	2.0	62.3	12.5	0.32	0.23
1,000	0.5	20.8	10.0	2.1	61.9	12.9	0.31	0.23
Cows nursing calves—average milking ability—first 3 to 4 months postpartum—10 lb milk/day								
800	0.0	17.3	10.2	1.8	58.2	10.1	0.30	0.22
900	0.0	18.8	9.9	1.9	57.3	10.8	0.28	0.22
1,000	0.0	20.2	9.6	2.0	56.6	11.5	0.28	0.22
1,100	0.0	21.6	9.4	2.0	56.0	12.1	0.27	0.22
1,200	0.0	23.0	9.3	2.1	55.5	12.8	0.27	0.22
1,300	0.0	24.3	9.1	2.2	55.1	13.4	0.27	0.22
1,400	0.0	25.6	9.0	2.3	54.7	14.0	0.27	0.22
Cows nursing calves—superior milking ability—first 3 to 4 months postpartum—20 lb milk/day								
800	0.0	15.7	14.2	2.2	77.3	12.1	0.48	0.31
900	0.0	18.7	12.9	2.4	69.8	13.1	0.41	0.28
1,000	0.0	20.6	12.3	2.5	67.0	13.8	0.39	0.27
1,100	0.0	22.3	11.9	2.6	65.2	14.5	0.38	0.27
1,200	0.0	23.8	11.5	2.7	63.7	15.2	0.36	0.26
1,300	0.0	25.3	11.2	2.8	62.6	15.9	0.36	0.26
1,400	0.0	26.7	11.0	2.9	61.7	16.5	0.35	0.26
Bulls, maintenance and slow rate of growth—regain body condition								
<1,300	For growth and development, use Table 1.1							
1,300	1.0	25.4	7.6	1.9	55.8	14.2	0.22	0.19
	1.5	26.1	7.9	2.0	59.7	15.6	0.24	0.19
	2.0	26.2	8.2	2.2	64.0	16.8	0.26	0.20
1,400	1.0	26.8	7.5	2.0	55.8	15.0	0.21	0.19
	1.5	27.6	7.7	2.1	59.7	16.5	0.23	0.19
	2.0	27.7	8.0	2.2	64.0	17.8	0.25	0.20
1,500	0.0	25.2	6.9	1.7	48.4	12.2	0.20	0.20
	1.0	28.3	7.4	2.1	55.8	15.8	0.21	0.19
	1.5	29.0	7.6	2.2	59.7	17.3	0.22	0.19
1,600	0.0	26.5	6.9	1.8	48.4	12.8	0.19	0.20
	1.0	29.7	7.3	2.2	55.8	16.6	0.22	0.19
	1.5	30.4	7.4	2.3	59.7	18.2	0.22	0.20

Table 1.2. Nutrients requirements of breeding beef cattle (nutrient concentration in diet dry matter).[a]

Weight (lb)	Daily gain (lb/day)	DM intake (lb)	Protein (%)	Protein (lb)	TDN (%)	TDN (lb)	Ca (%)	P (%)
Bulls, maintenance and slow rate of growth—regain body condition (continued)								
1,700	0.0	27.7	6.8	1.9	48.4	13.4	0.21	0.21
	0.5	29.6	7.0	2.1	52.0	15.4	0.20	0.19
1,800	0.0	28.9	6.8	2.0	48.4	14.0	0.21	0.21
	0.5	30.9	7.0	2.2	52.0	16.1	0.20	0.20
1,900	0.0	30.1	6.8	2.0	48.4	14.6	0.21	0.21
	0.5	32.2	6.9	2.2	52.0	16.8	0.20	0.20
2,000	0.0	31.3	6.8	2.1	48.4	15.2	0.21	0.21
2,100	0.0	32.5	6.8	2.2	48.4	15.7	0.22	0.22
2,200	0.0	33.6	6.8	2.3	48.4	16.3	0.22	0.22

Source: Adapted from National Research Council. 1984. *Nutrient Requirements of Beef Cattle*. National Academies Press, Washington, DC.

Forage Value

2

Ron Hathaway and
Gene Pirelli

Livestock producers in the western United States, including Oregon, are at an economic disadvantage relative to those in some other regions in North America because of relatively high winter feed costs. A ruminant animal consumes on average 2 to 3 percent of its body weight in dry matter each day. This equates to feeding 1.5 to 2.5 tons of conserved forage to mature cows or 0.25 to 0.5 ton to ewes during the winter feeding period. This volume of feed can represent more than 50 percent of the producer's input costs. The ability of Oregon cattle producers to compete with other regions of North America may relate to how effectively they can reduce winter feed costs while maintaining acceptable levels of beef cattle production.

In the grazing season, vegetative forage with an available height of 4 to 8 inches usually provides the nutritional needs of livestock. Outside of the grazing season, however, livestock depend on the producer to provide for their nutritional needs. It is during this period, when animals are fed conserved forage, that the nutritional management program plays an important part in maintaining the growth and condition of livestock.

In order to provide a ration that meets the nutritional needs of livestock, it is necessary to know the nutritive value of the forage. Forage value, whether hay or pasture, differs depending largely on stage of maturity, time, and weather at harvest.

Vegetative growth is the leafy growth that occurs in the early and middle parts of the growing season, and it is the most nutritious forage. Reproductive growth is the seed-producing stage of growth. It occurs later in the growing season, is a characteristic of mature plants, and is of reduced nutritive value.

Even if forage is harvested at the proper time, the nutrient content of the resulting hay or silage can vary widely. The amount and type of fertilizer used and the composition of the stand can contribute to variability.

Accurate forage analysis (see Chapter 3) is critical to profitable winter, nonpasture feeding programs. Even small deficiencies in protein and energy can lead to lower-than-desired performance levels of animals.

Once you determine the nutritive quality of the forage, you can decide how to allocate the feed. Ideally, you would formulate a complete and balanced ration, possibly including supplemental protein and/or energy (see Chapter 5). Alternatively, you could allocate the best quality feed to the animals with the highest nutrient requirements (see Chapter 1) and the lowest quality feed to those with lower requirements. The goal would be to use the feed in the most nutritionally appropriate manner.

Estimated and measured values

You can obtain a rough estimate of the value of forages through visual assessment, tables in nutrition books, and Extension publications. However, laboratory testing of your specific forage will provide the most accurate values for balancing livestock rations.

Once value has been determined, use the information to help provide balanced rations for your livestock. It can help you determine what supplements you need to add or simply the best way to use the feed you have.

Visual assessment

Several visual factors can assist in evaluating the nutrient value or quality of conserved forages. These factors are as follows.

Maturity. Maturity can be determined by observing bloom or bud stage and stem size. More abundant blooms or mature seed heads, fewer buds, and larger, woody stems indicate more mature forage.

Leafiness. Approximately two-thirds of the protein in forage is in the leaves. The ratio of leaves to stems is more important with legume forages than with grass forages.

Color. Forage that is not bright green may be damaged. Rain bleaches forage, heavy rain causes a dark brown or black color, and heat or fermentation causes browning. Yellowing can indicate overly mature forage.

Presence of foreign material. Weeds, chaff, sticks, and other matter that is not forage indicate lower quality hay.

Odor and condition. Hay that smells musty or is moldy indicates rain damage or baling at too high a moisture content. The result is lower quality hay and lower intake by animals.

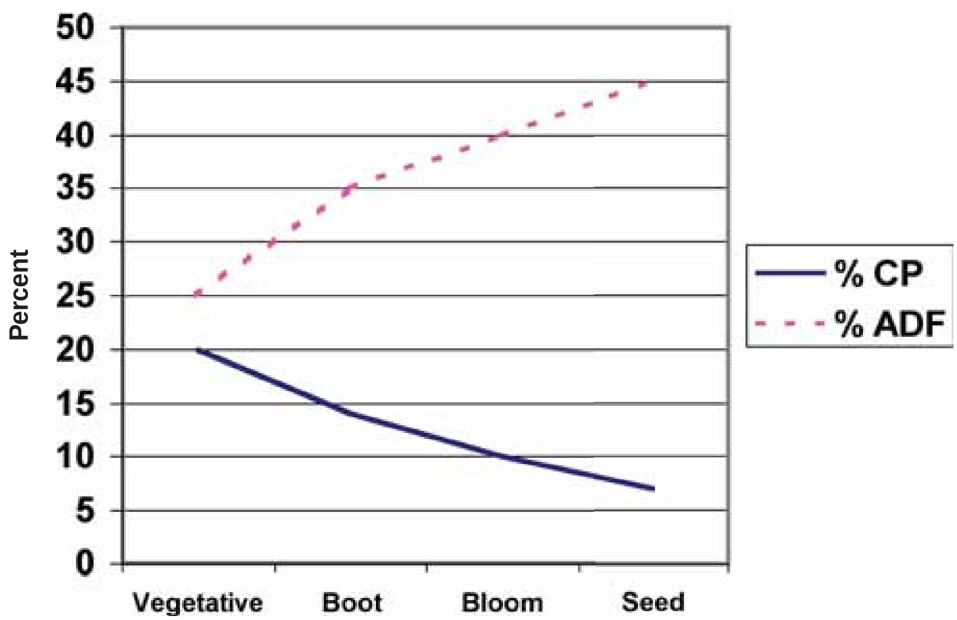

Figure 2.1—Change in crude protein (CP) and acid detergent fiber (ADF) with increasing maturity of cool-season grass forage based on laboratory tests in Oregon.

Maturity of the forage is one of the most important factors that determine proper harvest time. As forage plants or hays mature, the quality or feed value declines. As can be seen in Figure 2.1, the crude protein content decreases as the forage moves from a vegetative stage to seed head production. Additionally, the acid detergent fiber, which is an estimated measure of digestibility, increases during the same period. Increased acid detergent fiber means lower digestibility.

These changes in nutritional quality occur anytime during the growing season when plants move from a vegetative to a mature stage of production. During the most mature stage of plant growth (seed), protein and energy levels are too low to meet the nutrient requirements of most classes of livestock (see Chapter 1). Supplemental protein would be needed in order for livestock to utilize this very mature forage. Supplemental energy also might be needed, depending on animal requirements.

Table 2.1 shows data from a 6-year study in Washington, in which samples of perennial and annual ryegrass were harvested at different stages of maturity over an entire growing season. An example of the nutritional value for the boot, early boot, and vegetative growth stages is listed. Vegetative samples show much higher crude protein than the boot stage of growth. The early boot stage of grasses is considered to be the ideal cutting time to capture the highest yield and quality of a pasture or hayfield.

Stockpiled forage is pasture that was managed so as to keep the forage in the vegetative stage through the end of the growing season. As a result, the forage does not decrease in quality to the same extent as forage that is allowed to mature into the reproductive stage of growth. This standing forage is then utilized at a later date.

This practice works well in the dry climates of central and eastern Oregon, but on the west side of the Cascades the forage must be grazed before much rainfall accumulates. Rain reduces the value and desirability of the forage. Vegetative stockpiled forage is best utilized by about November 15 in western Oregon. The quality of this forage usually is intermediate relative to green, vegetative growth and dry, mature forage. Supplementation of animal diets may be required.

Table 2.1. Growth stage differences in nutritional quality (crude protein) of annual and perennial ryegrass in western Washington (average over a 6-year period).

	Crude protein (%)		
Cutting	Annual ryegrass	Perennial ryegrass	Growth stage[a]
1	9.75	10.56	Boot
2	15.56	16.94	Early boot
3	20.56	20.75	Vegetative
4	22.94	24.00	Vegetative
5	23.19	30.25	Vegetative

[a]The last three cuttings (vegetative growth) were taken during the summer and fall.

Book values and Extension publications

It has long been recognized that book value nutrient analyses for forages grown in other parts of the country do not accurately represent Oregon forages. To formulate winter beef diets, analyses for Oregon-produced forages are needed.

In order to develop a database of Oregon forages, more than 30 forages grown in Oregon were analyzed by Oregon State University researchers. These forages were evaluated for protein, energy, fat, fiber, and mineral content. In addition, the OSU research team compiled dry matter, crude protein, and acid detergent fiber results from hay surveys of more than 400 forage samples to create the Oregon Forage and Byproduct Library (see references). Mineral analyses are also included in the Library tables. There also is nutritional information on by-products as livestock feeds. This library is a valuable source of information to help producers estimate the nutritional value of locally produced or purchased forages.

Table 2.2 at the end of this chapter shows the nutrient content of common feeds used as protein and energy supplements.

Laboratory analysis

Ideally, you should have your forage tested each year for dry matter, crude protein, and acid detergent fiber (see Chapter 3). Laboratory analysis is by far the best way to develop your winter feeding program. Compare your forage analysis with the tables in the Oregon Forage and Byproduct Library and use the estimates of energy for beef cattle (TDN) and the other analyses to formulate your rations.

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Oregon Forage and Byproduct Library, Oregon State University, 112 Withycombe Hall, Corvallis, OR 97331-6702. Phone: 541-737-3431. Web: http://osu.orst.edu/dept/animal-sciences/foraglib.htm

Worksheet 2.1
Characterizing Your Forage Quality

What kind of conserved forage (hay, balage, or standing grass and/or legume mix) do you feed?

____

____

What was the stage of maturity when harvested?________________________________

____

What is your estimate of the crude protein and energy content of your conserved forage?

____

____

Describe your conserved forage in relation to the following factors: maturity, leafiness, color, foreign material, odor, and condition. ____

____

____

____

Do you have your conserved forage analyzed? __________________________________

What is the lab analysis of your feed? CP_________TDN_________Other, if known _____________

____

____

Table 2.2. Nutrient composition of common feedstuffs and range plants.[a]

Feedstuff	Dry matter (%)	TDN (%)	CP (%)	Ca (%)	P (lb)
Grazed plants					
Brome, fresh, early vegetative	34	74	18	0.50	0.30
Dropseed, sand, fresh, stem-cured	88	59	5	0.57	0.06
Galleta, fresh, stem-cured	71	48	5.5	1.05	0.07
Needle and thread grass, fresh, stem-cured	92	49	4.4	1.09	0.06
Orchardgrass, fresh, early vegetative	23	72	18.4	0.58	0.54
Orchardgrass, fresh, midbloom	31	57	11	0.23	0.23
Redtop, fresh	29	63	11.6	0.46	0.29
Ryegrass, fresh	27	68	10.4	0.55	0.27
Sage, black, browse, fresh, stem-cured	65	49	8.5	0.81	0.17
Sagebrush, big, browse, fresh, stem-cured	65	50	9.3	0.71	0.18
Sagebrush, bud, browse, fresh, late vegetative	32	52	17.5	0.60	0.42
Saltbush, browse, fresh, stem-cured	55	36	7.2	2.21	0.12
Saltgrass, fresh, post ripe	74	53	4.2	0.23	0.07
Squirreltail, fresh, stem-cured	50	50	3.1	0.37	0.06
Summer cypress (kochia), fresh, stem-cured	85	50	9	2.36	0.12
Timothy, fresh, late vegetative	26	72	18	0.39	0.32
Timothy, fresh, midbloom	29	63	9	0.80	0.30
Wheatgrass, crested, fresh, early vegetative	28	75	21.5	0.46	0.34
Wheatgrass, crested, fresh, full bloom	45	61	9.8	0.39	0.28
Wheatgrass, crested, fresh, post ripe	80	49	3.1	0.27	0.07
Winterfat, fresh, stem-cured	80	35	10.8	1.98	0.12
Other roughage					
Alfalfa hay, early bloom	90	60	18	1.41	0.22
Alfalfa hay, midbloom	90	58	17	1.41	0.24
Alfalfa hay, late bloom	90	52	14	1.43	0.25
Alfalfa hay, mature	91	50	12.9	1.13	0.18
Barley straw	91	40	4.3	0.30	0.07
Brome hay, sun-cured, late vegetative	88	60	16	0.32	0.37
Brome hay, sun-cured, late bloom	89	55	10	0.30	0.35
Corn, silage	33	68	8.1	0.23	0.22
Fescue hay, sun-cured, early vegetative	91	61	12.4	0.51	0.36
Fescue hay, sun-cured, late vegetative	92	48	9.5	0.30	0.26
Oat hay	91	55	9.3	0.24	0.22
Oat straw	92	45	4.4	0.24	0.06
Orchardgrass, hay, sun-cured, late bloom	91	54	8.4	0.26	0.30
Redtop, hay, sun-cured, midbloom	94	57	11.7	0.63	0.35

[a]TDN = total digestible nutrients; CP = crude protein; Ca = Calcium; P = Phosphorus

Table 2.2. Nutrient composition of common feedstuffs and range plants.[a]

Feedstuff	Dry matter (%)	TDN (%)	CP (%)	Ca (%)	P (lb)
Other roughage (continued)					
Ryegrass, hay, sun-cured, midbloom	86	60	8.6	0.65	0.32
Sedge hay, sun-cured	89	52	9.4	—	—
Sweetclover, yellow, hay, sun-cured, midbloom	87	54	15.7	1.27	0.25
Timothy hay, sun-cured, full bloom	89	56	8.1	0.43	0.20
Wheatgrass, crested, hay, sun-cured	93	53	12.4	0.33	0.21
Wheat hay	88	58	8.5	0.15	0.39
Wheat straw	89	41	3.6	0.18	0.05
Concentrates (protein and energy)					
Barley	88	84	13.5	0.05	0.38
Beet molasses	78	79	8.5	0.17	0.03
Brewers grains	92	66	28.1	0.29	0.54
Corn	88	90	10	0.02	0.35
Cottonseed meal	91	76	45.2	0.22	1.21
Milo	89	80	12.4	0.04	0.33
Oats	89	77	13.3	0.07	0.38
Soybean meal, 44%	90	85	47.7	0.29	0.68
Wheat	89	88	16	0.04	0.42
Wheat middlings	89	69	18	0.18	0.99

Source: Adapted from National Research Council. 1984. *Nutrient Requirements of Beef Cattle*. National Academies Press, Washington, DC.

Evaluating Feeds

3

Robert Pawelek and
Shelby Filley

As discussed in the previous chapter, nutrient content of feeds varies not only among different feed types, but also among batches of the same type of feed (hay lots, grain shipments, growth stage of pasture, etc.). The objective of sampling forages and concentrates is to obtain representative samples for laboratory analysis to estimate the value of feed for livestock.

Rapid feeding and turnover of grains and supplements may reduce the value of analyses compared to analyzing larger batches fed over a longer period of time. However, analyses completed even after the ration is consumed can detect seasonal differences that may influence future use.

Sampling feeds

Forages may be sampled as hay or standing pasture. Sampling methods include mechanical coring of bales with a hay probe, pulling hand-grab samples from bales or windrows, pulling hand-grab samples from standing forage, and clipping standing forage samples.

Accuracy depends largely on sampling method and lab technique. Having dependable samples can prevent unwelcome surprises. It is important to identify the sample by date, cutting, forage or concentrate type, pasture location, and owner before shipping it to the lab.

Remember: the key to accurate sampling of feed is to sample consistently and mix the samples thoroughly, especially if you plan to divide them.

Baled hay

There are several methods for sampling baled hay. The best technique is to use a mechanical coring probe made specifically for this purpose. Place the serrated edge on the side of the hay bale that is most resistant to puncture (usually the round side of a round bale or the small end of a square bale) and obtain a sample by drilling with a brace.

The sample should be as representative of the composition of the bales as possible. Repeat the process on several hay bales within the sampling lot. Sample hay from different fields or cutting times separately.

An older traditional method of obtaining forage samples is the hand-grab technique. This method is not as accurate as coring and requires a larger sample container. Hand samples do not provide consistently reliable results.

Pasture forage

Standing forage may be sampled by the hand-grab or clipping technique. Collect 20 subsamples and combine a sufficient amount to fill a 1-gallon reclosable plastic bag. In a pasture having a pure stand of forage, take samples randomly from different locations. If the pasture is a mixed stand of forages, it is important to sample only plants that animals will graze. Clip forage no shorter than 1 inch to avoid contaminating samples with soil. You can use scissors or a knife. Unlike hay, pasture forage is not normally dry when sampled. To avoid spoiling, air dry moist samples before shipping.

Grain

Grade of grain, along with protein and energy content, can vary widely. Periodically analyze the major feed grains for lactating and finishing diets. You also can request a lab analysis from the supplier. To sample, use a grain probe if available; otherwise, hand sampling is acceptable. It is best to take grain samples while the material is being off-loaded from the delivery truck. However, you can take five samples from different locations in the pile, bunk, bin, or truck. Combine all samples and ship in a clean, dry container.

Other feeds

Bagged or block products require several separate samples. A general guideline is to take samples from 10 percent of the bags or blocks in question. Take at least one handful per bag. Sample blocks by slicing or chiseling a chunk from each block.

Choosing a laboratory

A List of Analytical Laboratories Serving Oregon (EM 8677) is available in your county Extension office or on the Internet (http://eesc.oregonstate.edu/agcomwebfile/edmat/html/em/em8677/em8677.html). It contains contact information for labs that analyze forage samples. Prices and sample submission guidelines may differ among laboratories. Call the lab prior to taking the sample. Lab fees start at around $30.00 per sample and increase depending on analyses requested.

Analyses (lab tests to request)

There are many possible tests to perform on forages. Results for moisture, protein, and energy are the most important. Ask the lab to run the required analyses to give you this basic information. Standard analyses include percent dry matter (DM), percent crude protein (CP), percent acid detergent fiber (ADF), and percent neutral detergent fiber (NDF). Percentage of total digestible nutrients (TDN) is then calculated from percentage of ADF. Periodic analysis for basic mineral content also is helpful. Other analyses are nitrate nitrogen and trace mineral composition. Because non-standard analyses can be costly, request them only when needed.

Laboratory method

Wet chemistry uses chemical solutions to directly measure plant components in feed. This method is a well recognized and accepted way to measure the components of feed.

Near Infrared Reflectance Spectroscopy (NIRS) uses light transmitted through the sample to estimate the components of the feed. The estimates are made using mathematical equations based on previous wet chemistry data. Large amounts of data from many reference samples are required in order to create accurate equations for estimating feed components in this manner. While some forages lend themselves well to NIRS, and some laboratories have compiled the necessary data for accuracy, this is not always the case.

Be sure to discuss the use of wet chemistry versus NIRS with your county Extension faculty, nutrition consultant, or analytical lab before you decide which method to use. NIRS usually is less expensive and may be available overnight. Some labs can run wet chemistry samples overnight, while others take longer.

Lab report definitions

Acid detergent fiber (ADF)—A measure of cellulose and lignin. ADF is negatively correlated with overall digestibility (high ADF = low digestibility).

Adjusted crude protein—The crude protein adjusted for availability to the animal. Some proteins can be bound with fiber and are unavailable, especially in heat-damaged forages.

As-fed basis—A way to express percentage of nutrients in a feed, including moisture. As-fed will equal as-sampled or as-received, if the feed is not altered between sampling, testing, and feeding time.

Crude fat—Fat and other ether extractable compounds. Fat is an energy-dense nutrient and contains 2.25 times the energy found in carbohydrates and proteins.

Crude protein (CP)—An estimate of the protein content of the feed. Laboratories measure the nitrogen (N) content of the forage and then calculate crude protein using the formula CP = %N x 6.25.

Dry matter (DM)—The dry portion of the forage (not including the water).

Dry matter basis—A way to express percentage of nutrients in a feed, without the moisture. At some point in the calculations, DM must be converted to as-fed basis for the final mixing and feeding (see Chapter 5).

Minerals and vitamins—See Chapter 4.

Moisture—The water portion of a sample.

Net energy (NE)—An estimate of the energy in a feed that is available to the animal after allowing for energy lost during digestion and metabolism. Estimates for NE are divided into NE for maintenance (NEm) and NE for gain (NEg) and are more precise than TDN.

NEm is the energy value of a feed to maintain animal tissue without gain or loss of weight.

NEg is the energy value of a feed used for body weight gain above that required for maintenance.

Neutral detergent fiber (NDF)—A measure of hemicellulose, cellulose, and lignin, representing the fibrous bulk of the forage. NDF is negatively correlated with intake (high NDF = low intake).

Nonstructural carbohydrates (NSC)—Starches and sugars inside the cell that serve as energy sources for the animal.

Relative feed value (RFV)—A way to rank feed based on digestibility (ADF) and intake (NDF) potential. An RFV of 100 is considered the average score and represents an alfalfa hay containing 41 percent ADF and 53 percent NDF on a dry matter basis. The higher the RFV, the better the forage quality. RFV is used in feed marketing, not in balancing a ration for animals.

Total digestible nutrients (TDN)—A rough estimate of the feed energy available to the animal. It often is calculated from ADF.

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Worksheet 3.1
Sampling Plan for Your Forages

Each year, analyze new lots of hay or batches of grain (or other supplements) prior to the intended feeding period. You then can make and follow a plan for using this feed in an efficient manner. List the feeds you need to have analyzed.

1. ____________________

2. ____________________

3. ____________________

4. ____________________

5. ____________________

6. ____________________

Minerals and Vitamins

Important Little Things in Life

4

Ron Hathaway and James Oldfield

Two things that characterize Oregon's agriculture are its abundance of forage on range and pasture lands and its diversity, which makes possible the production of numerous crop and animal products. Diversity is a two-edged sword, however, because it means that different soil and weather conditions affect the composition of forages or other crops, and the effects sometimes are undesirable.

Suboptimal animal performance has been observed when cattle consume forage-based diets, despite an adequate supply of protein and energy. An insufficient supply of micronutrients, including minerals and vitamins, may be involved because cattle must receive all of the essential nutrients in proper quantities to maintain good health, grow, and reproduce at their maximum potential.

Minerals

A good example of the effect of diverse growing conditions is the concentration of mineral elements in forage, particularly the trace minerals, which normally are present in very small ("trace") quantities. Sometimes, these minerals are present at levels that are too low for good animal health, and so-called "deficiency diseases" result. On the other hand, elevated levels of these minerals sometimes cause toxicity.

Table 4.1 identifies the essential minerals as macrominerals or microminerals (trace). Macrominerals are required in relatively large amounts, and the requirements are expressed in percentages. Trace minerals, or microminerals, are required in smaller amounts, and the requirements are expressed in mg/kg (parts per million or ppm) of livestock diets. Many of the essential minerals usually are available in livestock feed in adequate

Table 4.1. Nutritionally essential minerals.

Macrominerals		Microminerals (trace)	
Calcium (Ca)	Potassium (K)	Cobalt (Co)	Manganese (Mn)
Phosphorus (P)	Chlorine (Cl)	Copper (Cu)	Molybdenum (Mo)
Magnesium (Mg)		Chromium (Cr)	Selenium (Se)
Sodium (Na)		Iodine (I)	Zinc (Zn)
Sulfur (S)		Iron (Fe)	Nickel (Ni)

amounts. However, in some cases feeds do not contain sufficient amounts, and supplementation is necessary to optimize animal performance.

Minimum requirements and maximum levels of minerals are shown in Table 4.2.

Macrominerals

Calcium (Ca) and phosphorus (P) are the minerals required in the largest amount by livestock. Calcium is the most abundant cation in an animal's body. Approximately 99 percent of the calcium is found in bones and teeth, with the remaining 1 percent distributed in soft tissues. Phosphorus is a major constituent of bones and teeth and is an essential component of organic compounds involved in almost every aspect of metabolism.

For optimum performance, Ca and P need to be present in the diet at required levels. In addition, the Ca to P (Ca:P) ratio is important. The ideal Ca:P ratio is approximately 1:1 to 2:1. With adequate amounts of P in the diet, a higher Ca:P ratio can be tolerated. In beef cattle, diets with a ratio as high as 7:1 have performed satisfactorily if levels of P are well above

Table 4.2. Mineral requirements and maximum tolerable level of minerals in beef rations.[a]

	Minimum requirement			
Mineral	**Growing and finishing cattle**	**Gestating cows**	**Early lactation cows**	**Maximum tolerable level**
Calcium (%)[b]	—	—	—	—
Cobalt (ppm)	0.10	0.10	0.10	10.00
Copper (ppm)	10.00	10.00	10.00	100.00
Iodine (ppm)	0.50	0.50	0.50	50.00
Iron (ppm)	50.00	50.00	50.00	1,000.00
Magnesium (%)	0.10	0.12	0.20	0.40
Manganese (ppm)	20.00	40.00	40.00	1,000.00
Molybdenum (ppm)	—	—	—	5.00
Nickel (ppm)	—	—	—	50.00
Phosphorus (%)[b]	—	—	—	—
Potassium (%)	0.60	0.60	0.70	3.00
Selenium (ppm)	0.10	0.10	0.10	2.00
Sodium (%)[c]	0.06–0.08	0.06–0.08	0.1	10.00
Sulfur (%)	0.15	0.15	0.15	0.40
Zinc (ppm)	30.00	30.00	30.00	500.00

[a]ppm = parts per million (1 ppm = 0.0001%; 1% = 10,000 ppm; 1 mg/kg = 1 ppm)
[b]Calcium (Ca) and phosphorus (P) requirements vary with age, weight, type of animal, and production level (pounds/day growth, stage of gestation/lactation, etc.). Young animals have high requirements because of bone growth. Also, high rates of gain or milk production and pregnancy increase Ca requirements. See Chapter 1 tables for amounts required.
[c]Percent sodium chloride (NaCl = salt)

Source: National Research Council. 1996. *Nutrient Requirements of Beef Cattle*. National Academies Press, Washington, DC. Web: http://www.nap.edu/

the required level and vitamin D level is high. Depressed performance has been observed with ratios below 1:1. Therefore, the ratio should not exceed 7:1 nor be less than 1:1.

Excess P in relationship to Ca can result in a very detrimental situation, even when Ca is at or above required levels. High levels of P can cause increased calcium resorption from the bone in adult animals. Urinary calculi (urolithiasis) are also caused by excess P. Stones in the kidney or bladder block urine, which can lead to death from uremia.

Calcium also has an interrelationship with other nutrients, and feeding higher levels of Ca for extended periods can have a detrimental effect on performance. Excess calcium can cause a deficiency of other essential elements, i.e., phosphorus, magnesium, iron, iodine, zinc, and manganese.

Consuming forage low in magnesium (Mg) leads to low blood levels of Mg (hypomagnesemia), which can cause grass tetany. Cattle in a state of severe magnesium deficiency become hypersensitive to tactile or sound stimuli and experience tremors. Convulsions and death usually follow.

Calcium and potassium (K) also can affect Mg blood levels by influencing Mg absorption. Thus, Mg concentration, as well as Ca and K levels, is important. By calculating a tetany ratio, K ÷ (Ca + Mg), you can estimate the risk of grass tetany.[1] A tetany ratio of greater than 2.2 represents a tetany-prone diet.

Microminerals (trace)

The levels of microminerals in forages or other feed crops may make the difference between profit and loss in an animal operation. For example, a deficiency of selenium may cause animals to suffer white muscle disease, which can interfere with growth and reproduction and may cause death.

An excess of molybdenum results in toxic molybdenosis and, because molybdenum ties up copper in the diet, may cause copper deficiency. Molybdenum levels of 5 to 6 ppm produce signs of molybdenosis. Some areas in Baker County have high levels of molybdenum in the soil, and animals show symptoms of copper deficiency, even though the forage contains normal levels of copper.

Deficiency symptoms often are similar for several microminerals, making diagnosis difficult. One specific symptom is goiter (a neck swelling), which indicates iodine deficiency.

The importance of trace minerals has been known for years. The need for copper and cobalt was discovered in the 1930s; for selenium in the 1950s. Yet, many livestock operators fail to ensure adequate quantities in rations for their animals. A 1996 audit of cow/calf feeds in 18 states showed deficiencies of various trace elements ranging from about 5 percent to nearly 50 percent of the 352 forage samples studied (Corah and Dargatz, 1996).

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[1]The tetany ratio is calculated on an equivalent weight basis (i.e., it does not use the percentage or ppm of the mineral as shown in the forage analysis report, but rather uses the amount of each element corrected for molecular weight.) Thus, the formula actually is:

(K concentration ÷ 39) ÷ [(Ca concentration ÷ 20) + (Mg concentration ÷ 12.1)]

The concentration of the elements must be on the same basis—percentage, ppm, or mg/kg.

To overcome a deficiency is fairly easy and generally not costly. One simply locates a source of the deficient mineral, usually a salt-mineral supplement, and adds it to the diet at a level to meet the animals' needs.

Preventing toxicity is more difficult, but it can be accomplished by eliminating the toxic feed from the diet (changing grazing sites, for example) or by adding a mineral that counteracts the effect of the toxic element, such as copper in cases of molybdenum toxicity.

Supplements seldom contain an element as such, but rather a salt of the needed element, such as sodium selenite in the case of selenium. Recently, interest has been shown in chelated minerals, which are thought to be more available to animals. A chelate is a combination of a mineral element and an organic substance, such as a protein or an amino acid. Chelated forms are more expensive, so consider using a blend of chelated and simple salt forms.

When supplementing feeds with essential trace elements, you'll need to calculate the amount of supplement to provide, based on the percentage of the needed element in the salt (see Worksheet 4.1).

Vitamins

Cattle require most of the vitamins needed by other mammals. However, ruminants are unique because rumen microorganisms can synthesize some essential vitamins. Synthesis by rumen microorganisms, supplies in natural feedstuffs, and synthesis in tissues meet most of the requirements.

Calves from adequately fed mothers have minimal stores of vitamins at birth. Colostrum is rich in vitamins, providing an immediate source of vitamins to the newborn calf. The ability to synthesize B vitamins and vitamin K in the rumen develops rapidly when solid feed is introduced into the diet. High-quality forages contain large amounts of vitamin A precursors and vitamin E. Vitamin D is synthesized by animal exposure to sunlight and is found in large amounts in sun-cured forages.

In ruminants, five classes of vitamins are important. Vitamin A likely is the most important. Vitamins D, E, K, and some of the B vitamins also are known to be essential. Supplemental vitamins can be added to the trace mineral salt mixture. Information on requirements, metabolic role, and signs of deficiency and toxicity is available in the references listed at the end of this chapter.

Vitamin A

When feed sources are likely to be low in vitamin A, supplementation is recommended to prevent potential problems with productive efficiency of cattle. Supplementing brood cows with vitamin A before (16,000 IU/day) and after (40,000 IU/day) the calving season can increase conception rates by 10 percent and decrease calf morbidity by as much as 50 percent as compared to a deficient state.

It is not uncommon for liver stores of vitamin A to be reduced when cattle consume a diet of low-quality, mature forage. Typically, 2 to 4 months of protection can be expected from stored vitamin A. Increasing dietary vitamin A by 5,000 IU per day can double the amount of vitamin A stored in the liver. Supplemental vitamin A may not always be necessary when cattle are grazing dormant rangelands, or if the cattle are fed properly cured and stored hay.

Vitamin E

Supplementation is recommended for brood cows consuming poor-quality forage during late pregnancy through early lactation. During the late stages of pregnancy, vitamin E concentration in the blood tends to decrease below marginal levels. Feeding supplemental vitamin E is an effective method of maintaining proper levels during this period.

Neonatal calves must receive dietary vitamin E because its placental transfer is very limited. However, it may not be necessary to supply supplemental vitamin E directly to the calf. Feeding an additional 1,000 IU of a-tocopherol (vitamin E) to cattle during the last trimester of pregnancy can increase antibody production and sequestration in the colostrum and increase vitamin E concentration in the colostrum by up to 30 percent. You can maintain plasma concentrations of vitamin E in the calf above the minimal level by continuing maternal supplementation into the early stages of lactation.

Vitamin D

Sunlight typically stimulates sufficient production of vitamin D in grazing cattle. Vitamin D status is improved more effectively by increasing the animal's exposure to sunlight than by dietary supplementation.

Vitamin K

Ruminal microorganisms generally synthesize and supply vitamin K in amounts sufficient to meet the ruminant animal's requirements. Supplemental vitamin K usually is justified only when cattle are suspected to have been exposed to vitamin K antagonists.

Consumption of a natural vitamin K antagonist (dicumarol) can be a problem if cattle ingest moldy sweetclover forage. Because dicumarol antagonizes vitamin K, an essential component of the blood clotting process, feeding moldy sweetclover hay to cattle may cause hemorrhage and uncontrollable bleeding.

Response to vitamin K therapy depends somewhat on differences in the dicumarol source and dosage. Therefore, prevention (avoid feeding moldy sweetclover hay) is a better alternative to supplemental treatments.

B vitamins

Microbial synthesis of the B vitamins in the rumen is thought to satisfy the ruminant's requirements. Supplementation with B vitamins should not be necessary under normal production situations, especially if cattle consume high-quality forage or are fed supplemental protein and/or energy that improves ruminal digestibility and subsequent microbial synthesis. Injections of B vitamins seem to be beneficial only to combat overt stress and disease.

Conclusions

Minerals and vitamins, whether essential or nonessential, can adversely affect an animal if included in the diet at excessively high levels. Feeding excessive amounts is costly in terms of dollars and animal performance. Having your forage sampled and analyzed for mineral content is the most practical way to assure that you are feeding an adequate, but not excessive, level.

Because of the availability of low-cost sources of vitamins A and E, consider regular supplementation of these vitamins to cattle fed low-quality forage. Supplementing other vitamins is not recommended, except under special circumstances.

It is in keeping with good husbandry and nutritional practice to maintain the intake of these important dietary constituents at required levels, but below the maximum tolerable levels. The benefits of such programs are seen in increased production efficiency. Aside from direct effects on reproduction, producers should benefit from cattle in better health.

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Worksheet 4.1
Practice Questions for Mineral Supplementation

1. A herd of cattle shows signs of copper (Cu) deficiency (scouring, light coat color), but when the forage they are grazing is analyzed, it shows 10 ppm Cu, which should be adequate. What do you suppose is causing the problem?

2. You wish to supplement a diet with copper, using copper sulfate as the source. Copper sulfate contains 39.81 percent Cu. How much copper sulfate must you add to supply 7 ppm Cu to a ton of feed? 1 ton = 908,000 grams (see example below)

3. Young calves are born with large swellings in the upper throat area. Can you relate this symptom to a micromineral deficiency? What is the common name for this deficiency disease?

Example for calculating amount of mineral compound to add to a desired mineral mix (and why you should consider a salt-mineral supplement that is formulated and mixed by a reputable dealer)\
You are losing some calves to white muscle disease and decide to supplement their diet with 0.1 part per million (ppm) of selenium (Se). You obtain some sodium selenite. How much should you add to the feed to get 0.1 ppm of selenium? Sodium selenite contains 45.65 percent Se.

When calculating small quantities, such as parts per million, it is easier to use small units (grams), rather than pounds. There are 454 grams in a pound, and 908,000 grams in a ton (2,000 pounds in a ton x 454 grams in a pound = 908,000 grams in a ton). A paper clip weighs about 1 gram.

1. You want 0.1 ppm Se in the 1 ton of feed (0.1 ÷ 1,000,000) x 908,000 grams per ton = 0.0908 gram Se per ton of feed.

2. Sodium selenite is 45.65 percent Se, so you need 2.19 grams of sodium selenite to get 1 gram of Se (100 ÷ 45.65 = 2.19).

3. You need 0.1989 (approximately 0.2) gram of sodium selenite to get 0.0908 gram of selenium per ton (2.19 x 0.0908 = 0.1989).

This is a very small amount to disperse evenly in a ton of feed, so it's best to make a premix. Add 0.2 gram of sodium selenite to 100 pounds of feed, mix thoroughly, and then add the other 1,900 pounds and continuing mixing. It may be best to have a feed dealer do the mixing since dealers are familiar with premixes and have efficient mixing equipment.

Resources

You can find information for calculating supplement values from the following resources.

- *The Merck Veterinary Manual* provides brief descriptions and percentage composition of all mineral supplements.
- *The Mineral Nutrition of Livestock* is a good source of information on animal symptoms of various deficiencies and supplementary levels of minerals needed to correct them.
- *Nutrient Requirements of Beef Cattle*

Ration Balancing

5

David Bohnert and
David Chamberlain

Feed costs are a major component of the total operating expense for most beef operations. By formulating and feeding balanced rations, you can conserve feed dollars while allowing for the most efficient level of production. Ration balancing depends on having accurate and reliable nutrient analyses of feedstuffs in addition to knowing the animals' nutrient requirements. Terms commonly used in ration balancing include the following.

Feedstuff—An ingredient used in formulating a ration.

As-fed—Refers to the moisture and nutrient content of feedstuffs normally fed to animals. This value must be corrected to account for moisture content (determination of dry matter) when balancing rations.

Dry matter—The portion of feed that remains after all the water has been removed. It contains the nutrients other than water.

Nutrients—The chemical substances found in feedstuffs that can be used, and are necessary, for the maintenance, production, and health of animals. The chief classes of nutrients are carbohydrates, fats, proteins, minerals, vitamins, and water.

Ration—The amount of feed an animal receives in a 24-hour period.

Balanced ration—A ration that supplies nutrients in the proper amount and proportion for an animal's maintenance, growth, lactation, and/or gestation. Information necessary to compose a balanced ration includes the nutrient composition of feedstuffs and the animal's nutrient requirements.

Nutrient composition—The amount of specific nutrients contained in a ration or feedstuff. Normally expressed as a percentage of dry matter.

Nutrient requirement—The amount of a specific nutrient that is required to meet an animal's minimum need for maintenance, growth, reproduction, lactation, and work. Nutritional requirements depend on the type, size, and physiological status of the animal.

TDN—Total digestible nutrients. A term used to express energy in feeds.

There are several ways to balance daily nutrient intake with daily nutrient requirements. All of these methods rely primarily on mathematical computations, which can be carried out by hand or with computer software. However, in order to formulate a balanced ration, you first must know the animal's nutrient requirements (see Chapter 1) and the nutrient composition of the feedstuffs to be included in the ration (see Chapters 2 and 3).

Send samples of feedstuffs to a certified analytical laboratory to determine nutrient composition (see Chapter 3). If this is not possible, ask your local Extension office for average values. However, there is no substitute for a lab analysis of your particular feedstuff. Feedstuff nutrient composition can be greatly influenced by stage of maturity, harvesting, processing, storage conditions, etc.

Methods of ration balancing

As mentioned previously, you can balance rations by hand or by using specifically designed computer software. We will describe one of the more common and useful methods of hand balancing a diet (Pearson Square) and review the positive aspects of computer programs.

Pearson Square

Use of the Pearson Square is relatively easy. You can use this technique to determine the proportions of two feedstuffs that will yield a ration containing a desired nutrient concentration. It can be used only for two feed materials; however, one or both can be a mixture. An example is provided here.

In this example, a ration is developed for a 500-pound heifer calf having a desired gain of 1.5 pounds/day. Her daily requirements are as follows (from page 12, Table 1.1, Chapter 1):

12.1 pounds dry matter intake
10.3 percent crude protein
68.5 percent TDN

The feedstuffs to be used in developing the balanced ration are listed in Table 5.1. Step by step, the procedure is as follows.

1. Balance for TDN. Draw a square and place 68.5 (the desired TDN level) in the center (Figure 5.1).
2. At the upper left corner of the square, write "meadow hay = 50," and at the lower left corner write "ground barley = 75." These numbers represent the TDN percentage in each feedstuff.
3. Subtract diagonally, smaller from larger (68.5 – 50 = 18.5; 75 – 68.5 = 6.5) and write the numbers on the right side of the square as shown in Figure 5.1.
4. Add the numbers on the right side of the square (6.5 + 18.5 = 25). These numbers indicate that a ration of 6.5 parts meadow hay and 18.5 parts ground barley will give a 68.5 percent TDN ration. This is a total of 25 parts.

Table 5.1. Feedstuffs used in Pearson Square example.

Feedstuff	Dry matter (%)	Total digestible nutrients (%)	Crude protein (%)
Meadow hay	92	50	6
Ground barley	88	75	11
Cottonseed meal	90	65	41

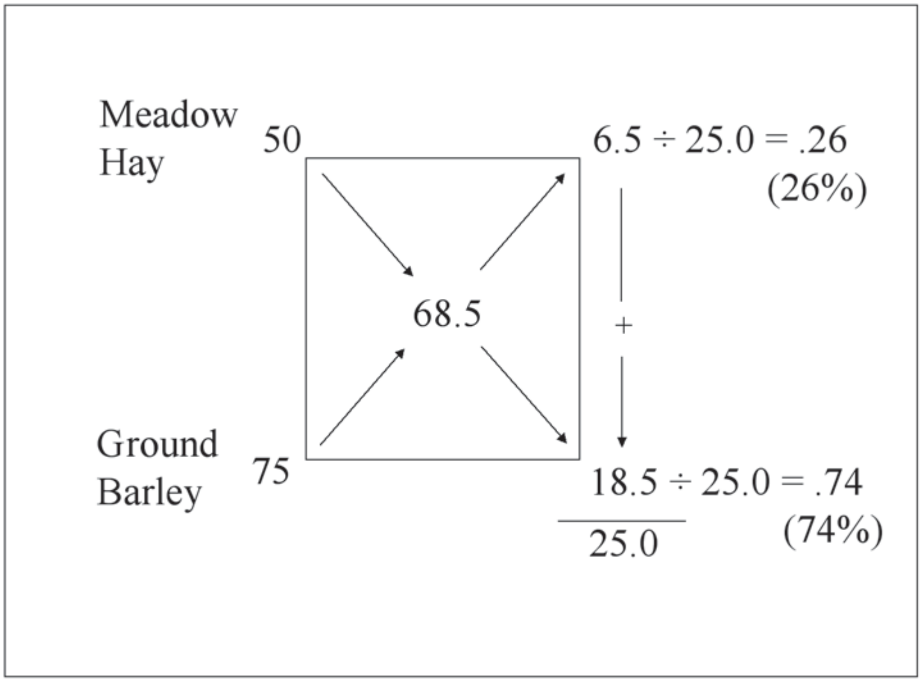


Figure 5.1—Balancing for TDN using a Pearson Square.

5. Divide the meadow hay and ground barley parts by 25 to get the preliminary percentages of hay (6.5 ÷ 25 = 26%) and barley (18.5 ÷ 25 = 74%).
6. Determine the crude protein concentration in the meadow hay and ground barley mixture. Multiply the percentage of each feedstuff in the mix by its crude protein content. Meadow hay is 26 percent of the mix and contains 6 percent crude protein. Ground barley is 74 percent of the mix and contains 11 percent crude protein. Add the results. Therefore, the crude protein concentration in the mix is:

Meadow hay	0.26 x 6	= 1.56%
Ground barley	0.74 x 11	= 8.14%
		9.70%

7. Determine whether crude protein is adequate. The concentration in the meadow hay/ground barley mix is 9.7 percent. The heifer requires 10.3 percent crude protein. Therefore, the crude protein content needs to be increased by adding a protein supplement (cottonseed meal in this example).

8. Use the Pearson Square method again to balance for crude protein. Draw a square and put 10.3 in the center (Figure 5.2).
9. Write "meadow hay/ground barley mix = 9.7" in the upper left corner, and "cottonseed meal = 41" in the lower left corner; these numbers indicate the crude protein percentage in each feedstuff.
10. Subtract diagonally, smaller from larger (10.3 – 9.7 = 0.6; 41 – 10.3 = 30.7), and write the numbers on the right side of the square.
11. Add the numbers on the right side of the square (30.7 + 0.6 = 31.3). These numbers indicate that a ration of 30.7 parts meadow hay/ground barley mix and 0.6 part cottonseed meal will give a 10.3 percent crude protein ration. This is a total of 31.3 parts.
12. Divide the meadow hay/ground barley mix and cottonseed meal parts by 31.3 to get the preliminary percentages of meadow hay/ground barley (30.7 ÷ 31.3 = 98%) and cottonseed meal (0.6 ÷ 31.7 = 2%).
13. Determine the pounds of dry matter that each feedstuff contributes to the total. Multiply pounds of dry matter required daily by the heifer (12.1) by the percentage for cottonseed meal (0.02, or 2 percent). Thus, the dry matter component made up by cottonseed meal is 12.1 x 0.02 = 0.24 lb.

    Subtract this amount (0.24) from the total dry matter intake (12.1) to determine how much dry matter will come from the meadow hay/ground barley mix (12.1 – 0.24 = 11.86 lb). There should be 11.86 lb of meadow hay/ground barley on a dry matter basis.

    To determine the amount of dry matter for meadow hay and ground barley, multiply 11.86 by the percentages of meadow hay and ground barley obtained in the first square (step 5): 26 percent meadow hay and 74 percent ground barley. 11.86 x 0.26 = 3.08 lb meadow hay and 11.86 x 0.74 = 8.78 lb ground barley.

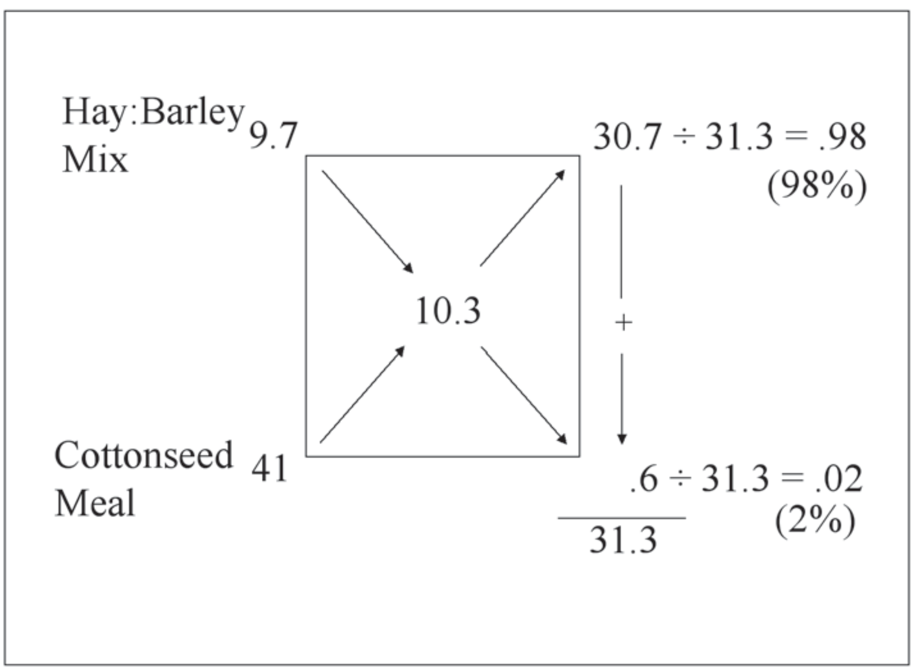


Figure 5.2—Balancing for crude protein using a Pearson Square.

14. Change each amount from a dry matter basis to an "as-fed" basis so that you know how much to feed. To do so, divide the pounds of dry matter for each feedstuff by the percentage of dry matter in each feed (see Table 5.1).

Meadow hay	= 3.08 lb ÷ 0.92 (92% dry matter)	= 3.35 lb
Ground barley	= 8.78 lb ÷ 0.88 (88% dry matter)	= 9.98 lb
Cottonseed meal	= 0.24 lb ÷ 0.90 (90% dry matter)	= 0.27 lb

A blank Pearson Square is included for your use as Worksheet 5.1.

Computer software

Computers provide immediate access to vast amounts of information concerning feedstuff nutrient content and animal nutrient requirements. As a result, computers and associated software can be powerful management tools to help lower feed costs and improve animal nutrition.

Computer programs designed for ration balancing include databases containing information on nutrient content and prices of hundreds of feedstuffs. Also, you can update databases with your current nutrient analyses and/or locally available feedstuffs. Most programs use management variables, such as class of beef cattle and physiological stage, to calculate nutrient requirements.

In addition, nutrition programs often provide an estimate of the quantity of feed consumed. Intake greatly influences the concentration of nutrients in a balanced ration, but it can be difficult to estimate. Intake is important because the total quantity of nutrients obtained by an animal in a given day depends on both the total intake and concentration of nutrients in the ration.

Ration balancing software also can allow you to store and change the price of individual feedstuffs. This enables you to obtain economic information about a particular ration in addition to nutrient analysis.

The ability to have feedstuff nutrient and price information available in a computer database is a major improvement over having to obtain information from tables and/or memory. Computers can evaluate numerous rations in the time it takes to formulate one ration by hand. In addition, you can evaluate and compare various feedstuffs to determine which are most cost-effective.

Exercise extreme caution when using computer programs to balance or evaluate rations and/or feedstuffs. Ration balancing software alone cannot determine a nutritional management program. Software is only one of many tools used in developing a complete nutritional program. There is no substitute for personal experience and common sense. Ration balancing programs can't determine whether a particular diet is prudent or practical. For example, nutritional software may suggest a diet consisting of 100 percent barley because it meets the animal's nutrient requirements. You need a knowledge of feeds and ruminant nutrition to realize that rations such as this are not practical.

Some commonly used computer programs from educational services include the following.

- SPARTAN, from Michigan State University (http://www.msu.edu/user/ssl/index.htm). Available for $100 from the MSU Software Distribution Center, 517-353-6740.
- TAURUS, from University of California–Davis (http://animalscience.ucdavis.edu/extension/software.htm). Available for $400 from the Department of Animal Science at the University of California Davis, 530-752-5886.
- AUTONRCAF, from Oklahoma State University (http://www.ansi.okstate.edu/software/). Available free of charge on the Web from the Department of Animal Sciences at Oklahoma State University.

Contact suppliers for updated cost of programs.

Important points to remember

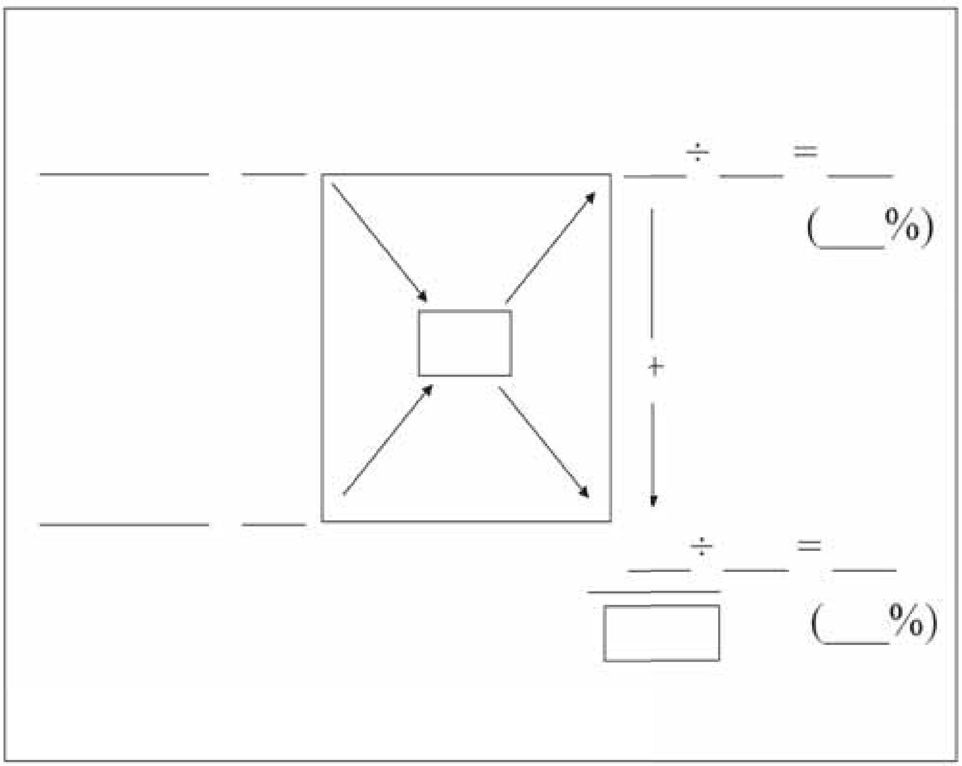
Successful ration balancing and/or evaluation requires accurate information regarding feedstuff nutrient composition and beef cattle nutrient requirements. You need to know the dry matter percentage of feedstuffs and understand how to convert as-fed values to dry-matter values.

In addition, a fundamental understanding of mathematics will improve your ability to formulate rations and interpret hand- and computer-generated diets. Your ability to balance and evaluate rations is only as good as the information used to develop them.

Efficient use of feedstuffs means providing a diet that meets an animal's nutritional requirements. Overfeeding, underfeeding, and/or feeding nutritionally unbalanced diets are inefficient management practices that increase feed costs and reduce profitability.

Worksheet 5.1
Pearson Square Diagram for Balancing Rations

Note: The Pearson Square can be used to balance rations containing two feed ingredients. The feed ingredients can be single feedstuffs or mixtures of feedstuffs.



Supplements and Supplementation Strategies

Used to Keep Livestock Productive During the Winter Feeding Period

6

Marni Porath and Jim Males

Having learned about nutrient requirements, feed value, and forage evaluation in previous chapters, you probably have discovered that the winter feed resources available on your operation don't always meet the requirements of your cows and heifers at every physiological state. Late-gestation and early-lactation cows have increased nutritional requirements. Bred heifers have these same requirements plus the elevated nutritional demands of body growth. These increased demands, combined with the lower quality feed that often is fed during the winter, commonly create a need for nutrient supplementation.

Determining how much and what kind of supplementation you need

There are three nutritional components that may need to be supplemented: protein, energy, and minerals. Supplements are feedstuffs that are added to the base forage to provide the nutrients required to support the desired level of production. The goal of supplementation is to supply the difference between the animal's requirements and the nutrients available through forage. Supplementation of protein and energy is discussed in this chapter. Chapter 4 discusses supplementation of minerals.

To develop a supplementation plan, begin by answering the following questions.

1. What is the physiological state of the animal?
2. What nutrients (and amounts of those nutrients) are required for the desired level of production? Keep in mind that cattle require quantities of nutrients, not percentages of nutrients. Percentages apply only when the animal's intake is the same as the predicted intake. It is best to break percentages down into quantities when evaluating rations and feeds (see Chapter 1).
3. What is the nutrient content of the forage available to you?
4. How much forage is available?

After you answer these questions, you should have a pretty clear idea of what you need to supplement. A common mistake is to "blanket supplement," or to buy a supplement that includes protein, minerals, and a little energy. These supplements are fine if they provide what you need, but often they cause producers to waste money supplementing something that isn't deficient.

A worksheet to help you determine what supplement is best for you is included at the end of this chapter (Worksheet 6.1).

Protein supplementation

Protein is a crucial part of the diet that often is deficient in winter-feeding situations. Both the animal itself and ruminal microorganisms need protein; hence, protein deficiency can severely depress animal performance. Research shows that protein deficiency also can suppress appetite and limit intake. Limited intake leads to an increased potential for other deficiencies.

If you determine that your forage is deficient in protein, you will want to consider: (1) what kind of protein supplementation is available, (2) the nutritional value of those supplements, and (3) the costs associated with using them.

Nonprotein nitrogen vs. natural protein

An important consideration in choosing a protein supplement is whether the supplement is nonprotein nitrogen (NPN) or natural protein. Nonprotein nitrogen is a good source of nitrogen, but it does not contain preformed amino acids. Natural proteins, on the other hand, are made up of amino acids.

Ruminal microorganisms can use NPN effectively as a nitrogen source in the production of microbial protein; however, NPN is not utilized as efficiently as natural protein. While utilization of NPN varies greatly (Table 6.1), you might expect 50 to 60 percent efficiency when feeding NPN with high-forage diets. The actual utilization depends on the source and the base diet of the animal.

Consider the above factors when pricing and purchasing a protein supplement. In addition, be aware that an NPN protein source should not exceed one-third of the animal's total protein requirements.

Table 6.1. Comparison of the utilization rate of nonprotein nitrogen (NPN) in liquid and dry forms when supplementing various feeds.

Study	NPN efficiency (as a % of natural protein)
Oklahoma—dry range	
Dry urea (6 studies)	92
Liquid urea (3 studies)	84
Maryland—corn stalks	
Liquid supplement	55
Southern Illinois—corn stalks	
Liquid supplement	14
Oklahoma—dry range	
Dry urea	37
Nebraska—dry range	
50% NPN/50% natural protein	74

Source: National Research Council. 1976. *Urea and Other Nonprotein Nitrogen Compounds in Animal Nutrition*. National Academies Press, Washington, DC.

Supplement options

Oilseed by-products such as cottonseed meal and soybean meal are common sources of protein supplements. These sources of natural protein contain more than 40 percent crude protein (CP) and a high density of energy. They work especially well when energy supplementation also is needed. The drawback to oilseed by-products is that they are relatively expensive.

Alfalfa or alfalfa cubes are another common protein supplement, especially in areas where they are readily available. Alfalfa is a good source of natural protein that provides the same benefits as other protein supplements when fed on an equal crude protein basis.

One potential drawback to alfalfa is that it doesn't have the high caloric density that some oilseed meals do. Thus, it may not be as effective if an energy source is also needed. One advantage is that it does not require special equipment or facilities to deliver it to the herd.

Commonly used sources of nonprotein nitrogen are urea and biuret. These products may be available as a liquid (typically with molasses as the carrier) or in a dry form (usually with a grain as the carrier). While these supplements may seem to be the most economical, keep in mind that NPN is not used as efficiently as natural protein.

Finally, high-quality grass hays may be a potential supplement for low-quality forages. They typically have a lower crude protein content

Table 6.2. Chemical composition of some potential feed ingredients used as sources of supplemental protein for low-quality forages.[a]

Protein source	CP (%)	% of CP		TDN (%)	ME (Mcal/kg)
		DIP	UIP		
Brewers grain	26	41	49	7	2.53
Canola meal	41	68	32	69	2.49
Coconut meal	22	62	38	64	2.31
Corn gluten meal	47	38	62	84	3.04
Cottonseed meal					
Mech	44	57	43	78	2.82
Sol-41% CP	46	57	43	75	2.71
Sol-43% CP	49	57	43	75	2.71
Distillers grain	30	45	55	90	3.25
Soybean meal-44	53	80	20	84	3.04
Soybean meal-49	50	65	35	87	3.15
Soybean, whole	40	65	35	94	3.40
Sunflower meal	26	38	62	65	2.35
Urea	291	100	0	0	0
Alfalfa hay					
Vegetative	22	86	14	64	2.31
Early bloom	20	84	16	62	2.24
Midbloom	17	82	18	60	2.17
Full bloom	13	77	23	56	2.02
Wheat middlings	18	77	23	83	3.00
Tall fescue hay	9	67	33	56	2.02
Meadow hay	13	77	23	60	2.17

[a]CP = crude protein; DIP = degradable intake protein; UIP = undegradable intake protein; TDN = total digestible nutrients; ME = metabolizable energy

Source: Torell, R. and J. Balliette. 1994. Pricing Protein and Energy Supplements. CL313 in *Cow–Calf Management Guide and Producer's Library*. Agricultural Communications, College of Agricultural and Life Sciences, University of Idaho, Moscow, ID.

than do protein supplements, but, depending on the base diet and their availability, they might be a viable option.

Cost analysis

Once you have determined how much protein you need to supplement, and what supplements are available, you need to do a cost analysis. It is essential that you compare the cost per ton of utilizable protein, not the cost per ton of supplement. Looking at the cost per ton of supplement can be very misleading.

Keep in mind that you are buying a specific nutrient, either protein or energy. Mineral requirements typically can be met with a less expensive free choice salt/mineral program. You do not want to pay for something you don't need!

The following steps will guide you through the cost analysis process.

1. Determine the total pounds of nutrients in 1 ton of supplement. To do so, multiply 2,000 pounds by the percentage of the nutrient in the supplement.

    Example:

    2,000 lb x 0.17 (17% CP alfalfa hay) = 340 lb of actual protein

2. Determine the cost per pound of nutrients. Divide the per-ton price of feed by the pounds of actual nutrient contained in a ton.

    Example:

    $100/ton ÷ 340 lb CP = $0.29/lb of protein

Therefore, the cost of protein in the alfalfa hay listed above is $0.29/pound ($580/ton). Use this value in your cost comparison.

If a protein supplement consists partially of NPN, you need to account for the lower utilization of NPN when figuring the cost per ton of protein. You want to figure the cost per ton of utilizable protein. Following is an example of how to make this adjustment.

1. Determine the amount of utilizable protein in the supplement.
   % NPN x utilization rate = % utilizable protein (from NPN)

    Example—liquid supplement:

    Crude protein, not less than 25%
    Includes not more than 18.5% equivalent protein from nonprotein nitrogen
    25% – 18.5% = 6.5% natural protein
    18.5% x 0.6 utilization = 11.1% utilizable protein (from NPN)
    6.5% natural protein + 11.1% utilizable NPN = 17.6% total utilizable protein

When calculating the cost per pound of protein in this supplement, you would use 17.6 percent as the protein content.

Energy supplementation

Energy is another nutrient that is commonly supplemented into low-quality forage diets during critical periods of the biological cycle. Energy supplementation leads to problems not encountered when supplementing for protein. High-energy feeds have been shown to decrease forage utilization. In other words, cattle tend to use energy supplements as a replacement or substitute for lower-quality forage instead of as a supplement. The degree to which they use energy as a replacement depends on the forage quality, the amount of energy in the supplement, the protein in the diet, and the energy source.

Supplement options

There are two general types of energy supplements: starch-based supplements and fermentable fiber sources. Starch-based supplements include grains such as corn, sorghum-grain, barley, oats, and wheat. Sources of fermentable fiber include soybean hulls, wheat middlings, beet pulp, and corn gluten feed.

Starch-based supplements can depress forage intake and digestibility by increasing the proportion of starch-digesting bacteria and decreasing the number of fiber-digesting bacteria within the rumen. While results vary, supplementation of grain at 0.4 percent of body weight or less typically does not depress the intake and digestibility of low-quality forage by beef cattle. At supplementation levels greater than 0.8 percent of body weight, forage intake and digestibility can be greatly depressed.

Supplementation with fermentable fiber sources generally does not decrease forage intake and/or digestibility as much as grain-based supplements. Fermentable fiber supplemented at rates of 0.2 to 0.8 percent of body weight has yielded favorable results.

Cost analysis

As in the case of protein, cost analysis of energy is an important step in determining which energy source is best for your operation. A number of different measures of energy are used in evaluating feedstuffs (see Chapter 3, page 30). Regardless of the measure you use, it is important that you be consistent. Cost analysis of energy follows the same steps as cost analysis of protein.

Frequency of supplementation

The frequency with which you supplement depends on whether you are supplementing protein or energy. Energy should be supplemented on a daily basis, as infrequent and irregular supplementation of energy can cause digestive problems.

Frequency of protein supplementation is more flexible. Ruminants have the ability to recycle absorbed nitrogen back to the rumen. Therefore, research has shown that infrequent protein supplementation is acceptable and safe as long as it results in the same total amount of supplement. Thus, you can save labor and time by supplementing every 2 to 7 days rather than every day.

Additionally, studies show less variation in weight change and supplement intake within a herd when supplementation is less frequent. There probably is less competition for the supplement when greater quantities are provided in a single feeding.

When practicing infrequent supplementation, be aware that you still must provide the same total amount of supplement, just in a larger quantity less frequently. Infrequent supplementation works best with natural protein supplements.

In the case of either protein or energy supplementation, be sure to provide adequate space for cattle to access the supplement. This will help prevent excessive variation in consumption within the herd.

Supplement placement

In many parts of the Northwest, stockpiled dormant forages are used as a winter feed resource. In this case, it is advantageous to feed supplements in a location that encourages more efficient use of the stockpiled forage. You might move the supplement site to increase use of the forage in specific areas and discourage the tendency of animals to remain at a supplement site where feed is not available. While the supplement may be necessary to meet the animals' nutrient requirements, it also is a potential tool for achieving management goals.

Other considerations

As in any management situation, the selection of protein and energy supplements is not always straightforward. Factors beyond price must be considered. The convenience, or feedability, of the product is important. Labor and time are valuable. It might be worth extra cost to drop off a feed tub or block once a week instead of having to load and feed one or several loads of alfalfa once or twice a week. Product availability also is critical.

Finally, consider what other nutrients you must supplement to balance the ration. If your ration is deficient in protein, energy, and minerals, and you can find one product that satisfies all of the deficiencies, it might be worth the extra cost. While vitamins and minerals can be supplemented in a free-choice salt/mineral supplement, the convenience of an all-in-one product may be worth the extra dollars. In this respect, each operation differs. It is up to you as the manager to use cost analysis and consider other factors to make the best choice for your operation.

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Worksheet 6.1
Determining Which Supplement Is Best for You

1. What supplements are available and what is their cost?
(Figure cost based on ton of nutrient, not on ton of supplement. Examples are included below to help you work through the cost comparison.)

Example supplements—nutrient content and cost[a]

Supplement	Energy content (% TDN)	Protein content (% CP)	NPN (%)	Cost/ton of supplement	Cost/ ton of nutrient
Alfalfa	60	19	0	$100	$526 (CP)
Liquid		25	18	$280	$1,573 (CP)
Barley	73	11	0	$200	$273 (TDN)
Tub		18	18	$250	$1,389 (CP)

[a]TDN = total digestible nutrients; CP = crude protein; NPN = nonprotein nitrogen

Alfalfa
0.19 (% crude protein) x 2,000 lb = 380 lb of protein/ton of alfalfa
$100/ton of alfalfa ÷ 380 lb of protein = $0.26/lb of protein x 2,000 lb/ton = $526.32/ton of protein

Liquid
25% – 18% = 7% natural protein
18% x 0.60 (NPN utilization) = 10.8% utilizable protein from NPN
7% natural protein + 10.8% utilizable NPN = 17.8% total utilizable protein
0.178 (% crude protein) x 2,000 lb = 356 lb of protein/ton of liquid
$280/ton of liquid ÷ 356 lb of protein = $0.79/lb of protein x 2,000 lb/ton = $1,573/ton of protein

Barley
0.73 (% TDN) x 2,000 lb = 1,460 lb of protein/ton of barley
$200/ton of barley ÷ 1,460 lb of TDN = $0.14/lb of TDN x 2,000 lb/ton = $273/ton of TDN

Protein tub
0.18 (% CP) x 2,000 lb = 360 lb of protein/ton of tub
$250/ton of tub ÷ 360 lb of protein = $0.69/lb of protein x 2,000 lb/ton = $1,389/ton of protein

continued on next page

Worksheet 6.1 (continued)
Determining Which Supplement Is Best for You

2. Other factors that are very important when choosing a supplement are: (1) how much of the supplement cows will need to eat to balance the ration, and (2) whether it is physically realistic for them to eat that amount of that particular supplement.

Review the amount of protein (pounds) needed to supplement the forage you are feeding (see Chapter 5) and enter below:

Pounds of supplemental protein required to meet the cows' protein requirement ________________lb

What type of protein supplement do you prefer to use (based on convenience and price/nutrient needed—see above)? ____

What is the percentage of protein in the supplement? ______________________________________

How much will each animal need to consume to meet its requirement?________________________

Example

Your mature cows are grazing on dry winter range. The grass they are eating is about 4.5% CP. Daily consumption is about 21 lb DM, and their protein requirement is 7.8%, or 1.6 lb of CP. You are planning to supplement with a baked protein tub containing 18% CP (all natural).

Pounds of supplemental protein required to meet the cows' protein requirement: ____0.655 lb_______
(21 lb DM x 4.5% CP = 0.945 and 1.6 lb CP – 0.945 = 0.655 lb)

What type of protein supplement do you prefer to use (based on convenience and price/nutrient needed—see above)? ____________Protein tub_____________________________________

What is the percentage of protein in the supplement?______18%______________________________

How much will each animal need to consume to meet its requirement?____3.64 lb______________
(See below for calculations.)

Calculations

0.18 (protein content of baked tub) x _____(amount of tub consumed) = 0.655 lb (protein needed to balance ration)

0.655 ÷ 0.18 = 3.64 lb of supplement consumed to balance ration

Many of the protein tubs suggest consumption levels of 1.5 to 2 pounds/animal. If each cow needs to eat 3.5 pounds of supplement from the tub, you might look for a different source of protein, where consumption likely would be greater.

Body Condition

The Beef Cow's Energy Gauge

7

Bruce Nisley and
Cory Parsons

Monitoring body condition is a management tool for evaluating the nutritional status and energy reserves of beef cattle. Nutritional requirements of cattle must be met in order to attain an optimal level of performance and efficient use of feed resources. Proper feeding strategies and ration balancing techniques have been discussed earlier in this publication. By following these techniques and strategies, you can provide the proper nutrients required to maintain or improve body condition, or nutrient reserves.

Cow body condition scoring (BCS) is a method of categorizing breeding animals by their degree of body nutrient reserves. This concept is not new. BCS simply puts a quantitative score on a procedure many cow/calf producers have followed for years to determine the body fat reserves of their herds.

BCS allows you to be more exact in describing your cows. It also provides a standardized tool for the beef industry to use when monitoring the energy reserves of the cow herd. Body condition scores range from 1 (severely emaciated) to 9 (very obese); see Table 7.1.

Monitoring body condition is an effective way to evaluate the herd's nutritional status. It also allows you to monitor the effectiveness of your feeding strategies and ration balancing. By assigning body condition scores, you will be better able to sort cows according to their nutritional needs, thereby improving the efficiency of your nutrition programs.

Table 7.1. Body condition score.

1	↑	Severely emaciated. Bone structure of shoulders, ribs, back, hooks, and pins is sharp to the touch and easily visible. Little evidence of 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	**Caution**	Very thin, no fat on ribs or brisket and some muscle still visible. Backbone easily visible.
4		Thin, with ribs easily visible but shoulders and hindquarters still show fair muscling. Backbone visible.
5		Moderate to thin. Last two or three ribs cannot be seen unless animal has been shrunk (held off feed and water for 12 to 18 hours). Little evidence of fat in brisket, over ribs, or around tail head.
6		Good, smooth appearance throughout. Some fat deposits in brisket and over tail head. Ribs covered and back appears rounded.
7	**Caution**	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 tail head. Square appearance.
9	↓	Rarely observed. Very obese. Animal's mobility may be impaired by excessive fat.

Source: Spitzer, J.C. 1986. *Influences of Nutrition on Reproduction in Beef Cattle*. W.B. Saunders Co., Philadelphia.

There is a strong link between body condition and weight change. As BCS increases or decreases, corresponding weight changes occur. Body condition of beef cows affects herd performance and profitability.

How to determine BCS

Body condition scoring can be done by physically palpating individual cows, visually appraising each cow, or scoring a representative sample of the herd. Palpation likely is more accurate, but it is not always practical due to large numbers of cattle or inadequate facilities.

Once properly trained, you can inspect cattle visually and accurately assign a BCS. When visually inspecting cattle and assigning BCS, it is important to know where to look on the cow and what to look for (Figure 7.1). Be careful to adjust for fill and hair coat, particularly in cold climates.

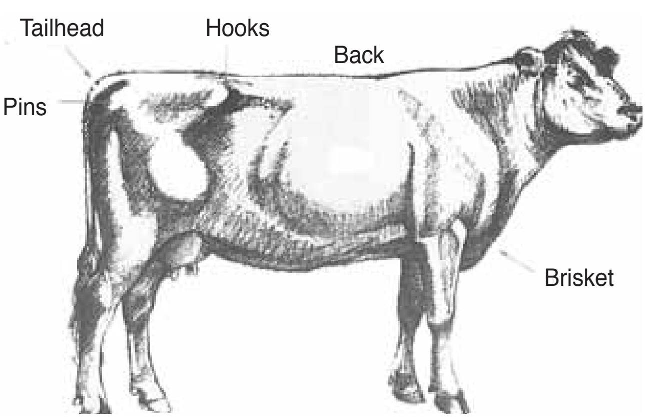
Always assign a BCS when animals have the same amount of rumen fill as the last time a BCS was assigned. Some producers prefer to assign BCS when the animals are shrunk (held off feed and water for 12 to 18 hours). This removes the rumen fill and makes it easier to see the ribs; thin cows with full rumens may seem to have more body condition than they actually do.

It may be advantageous to compare BCS to live weight. It has been reported that for every 1 BCS you can expect a 75- to 95-pound change in weight, depending on the frame size of the cow.

The ideal BCS

The BCS of beef cows varies depending on breed, environmental conditions, physiological conditions, and time of year. It is recommended that BCS of all cattle be taken and recorded at weaning and again at calving time. By doing so, you can sort thin cows from more fleshy ones and provide the thin cows with a nutritional supplement to increase their body condition prior to calving and rebreeding.

It is recommended that mature cows enter the calving season at a BCS of at least 5 but not more than 7. First-calf, 2-year-old heifers should



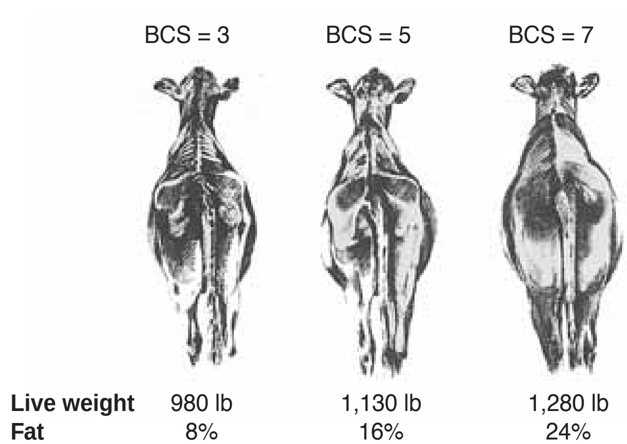


Figure 7.1—Body condition scoring of beef cattle.

enter the calving season at a BCS of at least 6 but not more than 7. A higher BCS is recommended for first-calf heifers because they are still growing. Consequently, they require more nutrients for continued growth, milk production, and repair of their reproductive tract for rebreeding. It also is recommended that you calve first-calf heifers 30 days prior to the main herd. This gives heifers an additional 30 days to rebreed and stay in the herd.

The consequences of thin cows

The cow is an amazing animal, with a nearly unequaled ability to survive on poor-quality forages. Yet even with her incredible ability to survive, she must prioritize nutrient allocation. When a cow doesn't have enough nutrients in her diet to meet all her needs, her body prioritizes how the limited nutrients will be used. The priorities are as follows (highest priority first):

1. Maintenance
2. Lactation
3. Growth in young cows
4. Reproduction

Thus, when a cow has inadequate feed and lacks body reserves, reproduction is the first thing to suffer and the last to recover. Reproductive losses can be devastating to ranch profitability.

Information collected from Texas producers involved in the Standardized Performance Analysis program (1991–1999) showed that the key measure of reproductive and productive performance was pounds of calf weaned per exposed female. This number is a function of both conception rate and days from calving to conception (postpartum interval). Cows that calve early in the calving season wean heavier calves. Thus, it is important not only to get cattle bred, but also to get them bred early in the breeding season.

Numerous researchers have shown that body condition has a significant impact on pregnancy rate and postpartum interval. It has been reported that only 50 percent of cows having a BCS of 4 were pregnant after a 90-day breeding season, while 90 percent of those with a BCS of 7 were settled in the same period (Figure 7.2). Others found a difference of 58 days in calving to conception between cows with condition scores 3 and 7 (Figure 7.2).

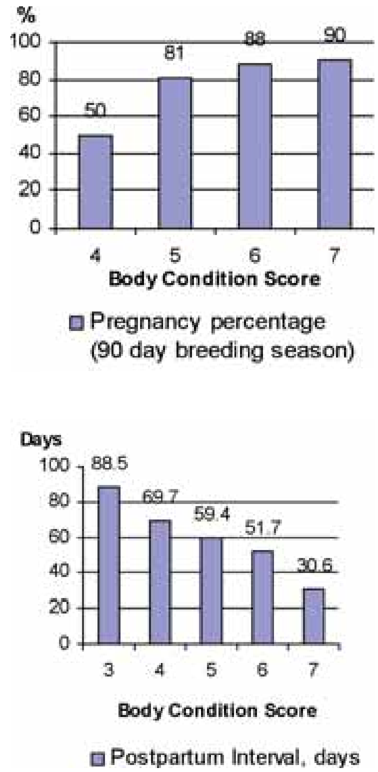


Figure 7.2—Effect of body condition score on reproductive performance. As BCS increases, the postpartum interval decreases and the pregnancy percentage increases.

Table 7.2. The relationship of body condition score to beef cow performance.

BCS	Pregnancy rate (%)	Calving interval (days)	Calf average daily gain (lb)
3	43	414	1.6
4	61	381	1.75
5	86	364	1.85
6	93	364	1.85

Low BCS has significant impacts on calf health and growth, and hence on profits. Researchers have reported an increased calf death loss of 5 percent for thin cows (92 percent survival in thin cows compared to 97 percent for cows in good condition). Furthermore, studies have shown reduced gains of 0.25 pound per day in calves from cows with a BCS of 3 as compared to those from cows with a BCS of 5 or greater (Table 7.2).

The cost of poor condition

We have discussed the production loss associated with underconditioned cows, but it is more powerful to look at economic losses and costs. Using an example herd of 100 cows, we have calculated the cost of mismanagement in Table 7.3. In this example, we compare BCS 3 to 5.

This example is not all-inclusive, but it helps to show some potential costs of thin cows. You would not expect to see an entire herd in such poor condition. However, it is not uncommon to see part of a herd as thin as BCS 3. Often, the thin cows are old cows or 2-year-olds weaning their first calf. Thus, in reality you would (hopefully) not lose $141 per exposed cow, but possibly a percentage of this amount.

How and when to improve body condition score

There is no doubt that thin cows have lower production and produce less income. Thus, you must adopt the most economically efficient management. The ideal is to optimize production at minimum expense. Thus, you need to put condition on the cows at the most efficient times and minimize condition loss when economically viable.

Table 7.3. Economic comparison of BCS 3 to BCS 5 cow herds.

	BCS 3 herd (100 bred cows)	**BCS 5 herd (100 bred cows)**
Cows exposed to produce 100 bred cows	132 cows exposed 76% conception	106 cows exposed 94% conception
Calf survival	92 head of calves weaned (92%)	97 head of calves weaned (97%)
Age at weaning, adjusted for postpartum interval (PPI)	Calves 180 days at weaning (88.5 days PPI)	Calves 210 days at weaning (59.4 days PPI)
Calf weaning weight (using 85-lb average birth weight and adjusted weaning age)	373 lb Gain 1.6 lb/day	474 lb Gain 1.85 lb/day
Pounds of weaned calf per herd	34,316 lb total	45,978 lb total
Value of calves at weaning	$105/cwt = $36,032	$95/cwt = $43,679
Income per cow calved	$360	$437
Income per cow exposed	$273	$412

First, you must decide which cattle really need more condition. If cattle are already in good flesh, you don't want to expend additional resources. However, you may have some cows with BCS ranging from 3 to 7.

There is no value in overfeeding already well-conditioned cows, so sorting into feeding groups likely is the best option. Three groups often are recommended, but in most operations two groups are more practical.

If the herd is sorted into two groups, the first likely would include thin mature cows with BCS of 4 or less and 3-year-old and younger cows with BCS of 5 or less. Feed this group to gain condition. Feed the remainder of the herd (those with an adequate BCS) a maintenance ration.

To improve a cow's BCS by 1 point, she will need to gain 75 to 95 pounds. To achieve this gain, you must be aware of what is happening at each phase of the cow production cycle (Table 7.4.), as well as what nutritional and feed resources are available. For example, in a spring calving herd, calves are weaned in late fall, when the fetus in the pregnant cow is developing slowly. From a production sense, this is a practical time to consider increasing body condition. Yet, it may be a time of limited-quality feed.

Evaluate what will work best to maintain and add condition to your herd. It is important to estimate the number of pounds to be gained in order to reach the desired condition score and to formulate the ration accordingly. Balancing rations is discussed in Chapter 5.

There are no simple management solutions to optimize production. However, by making good decisions, you can improve your herd performance and pay dividends for the time spent making decisions.

Table 7.4. Estimated weight gain from weaning to calving to achieve desired BCS.

Current BCS	Desired BCS	Approximate amount of body weight gain
1	5	Needs to gain more than 350 lb Economics are questionable
2	5	Needs to gain 300 to 350 lb Economics are questionable
3	5	Needs to gain 200 to 300 lb
4	5	Needs to gain 150 to 200 lb
5	5–7	Needs to gain weight of fetus (100 lb)
6	5–7	Needs to gain weight of fetus (100 lb)
7	5–7	No weight gain needed
8	5–7	Probably can lose from 50 to 150 lb (during midpregnancy)
9	5–7	Probably can lose from 100 to 200 lb (during midpregnancy)

Worksheet 7.1
Application of Body Condition Scoring

1. What would you estimate your cows' BCS to be at calving?

1 2 3 4 5 6 7 8 9

2. What would you estimate your cows' BCS to be at weaning?

1 2 3 4 5 6 7 8 9

3. Approximately how many pounds on average (if needed) would each cow need to gain to reach "ideal" condition? ___________________________ (1 BCS = 75 to 95 pounds)

4. When would be the best time to improve the BCS of underconditioned cows in your herd?

____

____

5. Assume the difference in postpartum interval between BCS 4 and BCS 5 cattle is about 10 days and your herd averages BCS 4. How many pounds might you add at weaning by having calves born 10 days earlier? Calves usually gain from 1.6 to 2.2 pounds per day.

Estimated gain (in pounds per day) ___________ x 10 days = ______ pounds per head
x _______ number of calves sold at weaning = __________ pounds of lost opportunity at weaning

It is important to remember that weaning weight is only one area of lost performance for thin cows.

Heifer Nutrition and Development

8

Peter Schreder

Adequate heifer development is critical to the long-term sustainability of a productive cow herd. Replacement heifers are the foundation on which your herd is built. Whether heifers are purchased or self-raised, they represent your long-term herd productivity.

The improved profitability resulting from calving heifers for the first time as 2-year-olds rather than as 3-year-olds has been long proven. Also, research indicates that well-developed heifers that calve early in their first calving season continue to calve early in subsequent calving seasons. Consequently, they wean heavier calves throughout their lifetimes, compared to heifers that calve later in their first calving season.

Although aspects such as breed characteristics and genetics are important, meeting animals' nutritional requirements is a key part of developing productive heifers. The nutritional program for developing heifers should not require expensive purchased feeds. Target gains often can be met with little energy and protein supplementation.

Divide the heifer nutritional program into stages: weaning, weaning to breeding, breeding to first calving, first calving to second breeding, and the second postcalving period. Each stage is discussed below.

Weaning

Weaning is a time of stress, and it is a time when heifer calves' development can be retarded. A good weaning program typically lasts 4 weeks and should overcome the weight loss and nutritional stress of the weaning process. Prior to weaning, contact your veterinarian to set up a vaccination and preconditioning schedule.

A practice that is proving to be effective is fence line weaning. In a recent study, researchers weaned 248 calves and placed them in two feed yard pens. The dams of the calves in one pen were allowed to stay in the area just outside the pen. The other dams were removed from the area. After 10 days, there was no significant difference in weight gain, immune function, or physiological indicators of stress. But there was much less fence walking and bawling in calves weaned next to their dams. Fenceline weaning seemed to be a calmer process.

When weaning, get the calves started on high-quality hay and a palatable grain mix, and provide the recommended level of trace minerals (see Chapter 4, Table 4.2). The grain mix should contain a protein supplement (soybean meal, cottonseed meal, etc.) and some molasses to increase palatability.

It is important to provide a palatable, high-quality grain mix because dry matter intake normally is depressed during weaning and, consequently, nutrient intake is decreased. The grain mix should allow the heifers to obtain a significant amount of their required nutrients from a small amount of supplement.

You can get calves to the feed bunk quickly by feeding a familiar ingredient (such as high-quality hay or alfalfa). You might begin by providing high-quality hay in the feed troughs, in addition to about 1 pound/head/day of ground barley or corn oats barley (COB) and 1 pound/head/day of soybean meal.

Once the animals have gotten used to the grain mix (usually 5 to 7 days), you can increase the quantity to 2 pounds/head/day grain and 2 pounds/head/day soybean meal. After about 4 weeks (to monitor for health disorders and allow adequate time for adaptation to life without "mom"), you can turn the calves out on high-quality pasture and initiate the growing program.

Postweaning

The postweaning period lasts from the end of the weaning phase to the time the heifers are bred. The growth rate during this phase should allow heifers to reach their target weight for breeding, or approximately 60 to 65 percent of mature weight. At this weight, most heifers reach puberty before the breeding season. Since the pubertal estrus is less fertile than later cycles, it is wise to plan for heifers to reach their target weight at least 21 days prior to the breeding season.

If the target weight is not reached, breeding will be delayed. Conversely, with excessive growth and condition, the developing udder fills with fat, retarding mammary development and resulting in poor milking ability.

The daily gain of heifers typically needs to be about 1.25 pounds during this stage. You can accelerate the growth rate so that heifers lagging in development can catch up, but the gain should not exceed 2 pounds/day.

Adequate growth often can be achieved with high-quality pasture alone. During wintering in western Oregon, grazing on small grain, ryegrass, or fescue pastures can result in adequate gain.

Average-quality hay or pasture rations require supplementation, as determined by a forage analysis. The supplement may need to provide protein, energy, or both. A mineral mix containing an ionophore can stimulate performance if forage quality is marginal compared to the heifer's requirements. Chapter 1 discusses the protein, energy, and mineral requirements of heifers at different stages of development.

Worksheet 8.1 (at the end of this chapter) will help you calculate required heifer gains.

Breeding to calving

It is recommended that first-calf heifers weigh 75 to 85 percent of their mature weight at first calving. Heifers need to gain approximately 1 pound/day from the time they are bred until calving. In western Oregon, this gain usually is achieved on pasture alone.

While it might seem easy to achieve this performance goal, do not turn heifers out to pasture and ignore them before calving. Take steps to assure adequate body condition of heifers precalving, and pay extra attention to mineral and vitamin requirements during the last trimester.

Heifers should have a body condition score of at least 6 (see Chapter 7) entering the calving season. If heifers are in poor condition, place them on a higher level of nutrition. It is difficult to improve their condition as they approach calving, and it is especially difficult after calving. Improving heifer body condition score will increase the quantity and quality of colostrum, decrease the time from calving to estrus, decrease death loss in calves, and increase calf vigor.

Calving to rebreeding

If a heifer that calves in good body condition loses condition rapidly after calving, her reproductive rate may be reduced. Heavy-milking heifers are especially prone to rapid weight loss, resulting in delayed cycling.

Plan to provide the lactating first-calf heifer the highest quality hay or pasture available, and be prepared to provide a grain supplement sufficient to maintain body condition above 5. Provide a good, palatable mineral supplement balanced specifically for early lactation (see Chapter 4).

It is important to understand a cow's order, or hierarchy, of nutrient allocation. Nutrients are utilized in the following order: (1) maintenance, (2) lactation, (3) growth, and (4) reproduction (see Chapter 7). It is easy to see that a cow in a negative energy and protein state will experience decreased reproduction and conception. Reproduction is a luxury (not a necessity) for the heifer; however, it is essential for producer profitability.

Second calving

Second-calf cows often are the most difficult to get bred; many producers notice the highest rate of open cows in this age bracket. When the young cow is preparing for her second calf, she should be about 90 percent of her mature body weight. She should maintain a body condition of 5 or better after calving.

This cow is still growing, especially in the case of later maturing breeds, so she needs a slightly higher level of nutrition than do mature cows. In general, however, if milk production is moderate and forage quality is high, 3-year-old cows can be managed with mature cows. Some producers find it easier to group 3-year-olds with 2-year-olds, but in either case it is difficult to target nutrition specifically to this group.

Summary

The development program for heifers is divided into stages. Providing heifers with nutrition to meet the target gains and weights indicated will result in a high level of fertility and calf health. Providing heifers with a good start also improves the overall profitability of the beef operation.

Many producers develop their own heifers. It is important to examine the possibility of purchasing 2-year-old replacement heifers from a producer who specializes in developing quality heifers. Worksheet 8.2 will help you compare the cost of raising versus purchasing replacement heifers.

Worksheet 8.1
Calculating Required Heifer Gains

	Example	Your herd	Notes
Mature cow size	1,100 lb		
Target weight at breeding (65% of mature weight)	715 lb		1,100 x 0.65 = 715
Current weight	450 lb		
Total gain needed	265 lb		715 – 450 = 265
Current date	October 15		
Start of breeding season	June 1		
Length of feeding period	225 days		

Worksheet 8.2—Sample
Change in Net Income if Replacement Heifer Is Purchased

Positive effects

$ per head

Added returns

1. Net returns from sale of raised heifer calf (535 lb x $0.80/lb) $428.00
2. Interest on net returns from heifer calf sale
   $428 [line 1] x 0.11 (interest rate) x 15 months[a] ÷12 .... $58.85
3. Total added returns [line 1 + line 2] $486.85

Reduced cost[b]

4. Value of hay fed to raised heifer calf (1.82 tons x $75/ton) $136.50
5. Value of pasture grazed by raised heifer calf $55.14
6. Value of salt and minerals for raised heifer calf $15.97
7. Other feed costs for raised heifer calf $11.59
8. Veterinary and medicine expenses for raised heifer calf $5.00
9. Value of labor and management for raised heifer calf (8 hours x $10/hr) $80.00
10. Raised heifer calf's share of bull cost
    $840 (annual bull cost) ÷ 25 females per bull x 15 months[a] ÷12 .... $42.00
11. Other nonfeed costs for raising heifer calf[c] $50.00
12. Interest on feed and nonfeed costs for raised heifer calf
    396.20 [sum of lines 4–11] ÷ 2 x 0.11 (interest rate) x 15 months[a] ÷12 .... $27.24
13. Total reduced cost [sum of lines 4–12] $423.44
14. Total positive effects [line 3 + line 13] $910.29

Negative effects

Added cost

15. Cost of purchased replacement heifer $750.00
16. Other costs for purchased replacement heifer[b] $0
17. Total added cost [line 15 + line 16] $750.00

Reduced returns

18. Reduction in returns experienced if replacement heifer is purchased[b] $0
19. Total negative effects [line 17 + line 18] $750.00

Financial analysis

20. Change in net income per heifer replacement [line 14 – line 19] $160.29
21. Change in annual net income for herd
    $160.29 [line 20] x 20 (number of heifer replacements required per year)
    x (12 ÷ 15 months[a]) $2,564.64
22. Average annual rate of return
    $160.29 [line 20] ÷ $750.00 [line 15] x (12 ÷ 15 months[a]) x 100 .... 17.1%

[a]The numerator (lines 2, 10, 12) and denominator (lines 21, 22) should equal the number of months between the sale of the heifer calf and the purchase of the replacement heifers.

[b]Enter only the effects occurring during the period between the sale of the heifer calf and the purchase of the replacement heifer.

[c]May include repairs, utilities, fuel, insurance, etc.

Source: Nelson, D.D. and G.S. Willett. 1992. *Analyzing the Economics of Raising versus Buying Beef Replacement Heifers*. EB17. Washington State University Cooperative Extension.

Worksheet 8.2—Blank
Change in Net Income if Replacement Heifer Is Purchased

Positive effects

$ per head

Added returns

1. Net returns from sale of raised heifer calf (______ lb x $______/lb) ....$________
2. Interest on net returns from heifer calf sale
   $______[line 1] x ______ (interest rate) x ______months[a] ÷12...$________
3. Total added returns [line 1 + line 2] ....$________

Reduced cost[b]

4. Value of hay fed to raised heifer calf (_____ tons x $______ /ton) ....$________
5. Value of pasture grazed by raised heifer calf ....$________
6. Value of salt and minerals for raised heifer calf ....$________
7. Other feed costs for raised heifer calf ....$________
8. Veterinary and medicine expenses for raised heifer calf..$________
9. Value of labor and management for raised heifer calf (_____ hours x $________/hr) ....$________
10. Raised heifer calf's share of bull cost
    $_________ (annual bull cost) ÷ ______ females per bull x ______months[a] ÷12....................$________
11. Other nonfeed costs for raising heifer calf[c] ....$________
12. Interest on feed and nonfeed costs for raised heifer calf
    ______ [sum of lines 4–11] ÷ 2 x _______ (interest rate) x _____months[a] ÷12 .... $________
13. Total reduced cost [sum of lines 4–12]..$________
14. Total positive effects [line 3 + line 13]...$________

Negative effects

Added cost

15. Cost of purchased replacement heifer ....$________
16. Other costs for purchased replacement heifer[b] ....$________
17. Total added cost [line 15 + line 16]..$________

Reduced returns

18. Reduction in returns experienced if replacement heifer is purchased[b] ....$________
19. Total negative effects [line 17 + line 18] ....$________

Financial analysis

20. Change in net income per heifer replacement (line 14 – line 19)...$________
21. Change in annual net income for herd
    $__________ [line 20] x ______ (number of heifer replacements required per year)
    x (12 ÷ _______months[a]) ....$________
22. Average annual rate of return
    $________ [line 20] ÷ $______ [line 15] x (12 ÷ ______months[a]) x 100 ...._______%

[a]The numerator (lines 2, 10, 12) and denominator (lines 21, 22) should equal the number of months between the sale of the heifer calf and the purchase of the replacement heifers.

[b]Enter only the effects occurring during the period between the sale of the heifer calf and the purchase of the replacement heifer.

[c]May include repairs, utilities, fuel, insurance, etc.

Source: Nelson, D.D. and G.S. Willett. 1992. *Analyzing the Economics of Raising versus Buying Beef Replacement Heifers*. EB17. Washington State University Cooperative Extension, Pullman, WA.