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RANGE NUTRITION ON CALIFORNIA ANNUAL GRASSLANDS

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FORAGE PRODUCTION AND UTILIZATION

Matching the nutrient demands of livestock and the nutrients supplied by range forage comprises a real balancing act for a considerable portion of each year. Operators should know the basic needs of their stock at all times during the production cycle. However, the changes in nutritional status of the animal's diet from day to day as the season progresses is not so well known. Range forage nutritional values may vary greatly from one location to another. The examples of nutrient composition presented in this report are useful indicators of general trends and may aid in supplementation decisions.

Forage Quality

Measures of forage quality such as protein, energy, vitamins and minerals follow a declining trend as the growing season progresses (Figure 1). Conversely, measures of low quality such as fiber and lignin increase as forage plants mature. Seasonal forage quality and phenological stage of several important annual range forage species are reported in Tables 1-3. Note that crude protein levels of the grasses are often in excess of 20 percent at the start of growth in fall but decline at different rates to 5 percent or less by the end of the season. Seasonal trends of forbs (herbaceous plants other than grasses) are similar, although protein levels of legumes are higher than grasses in mid to late season. However, the leaves of forbs, where nutrients are often concentrated, may shatter when the plant drys. This then renders those nutrients unavailable.

Cyclical changes in phosphorus, copper, calcium, potassium and sodium in range forage at the U.C. Sierra Foothill Range Field Station are shown in Figures 2-6. Generally these nutrients are greatest in the spring and lowest during the dry season.

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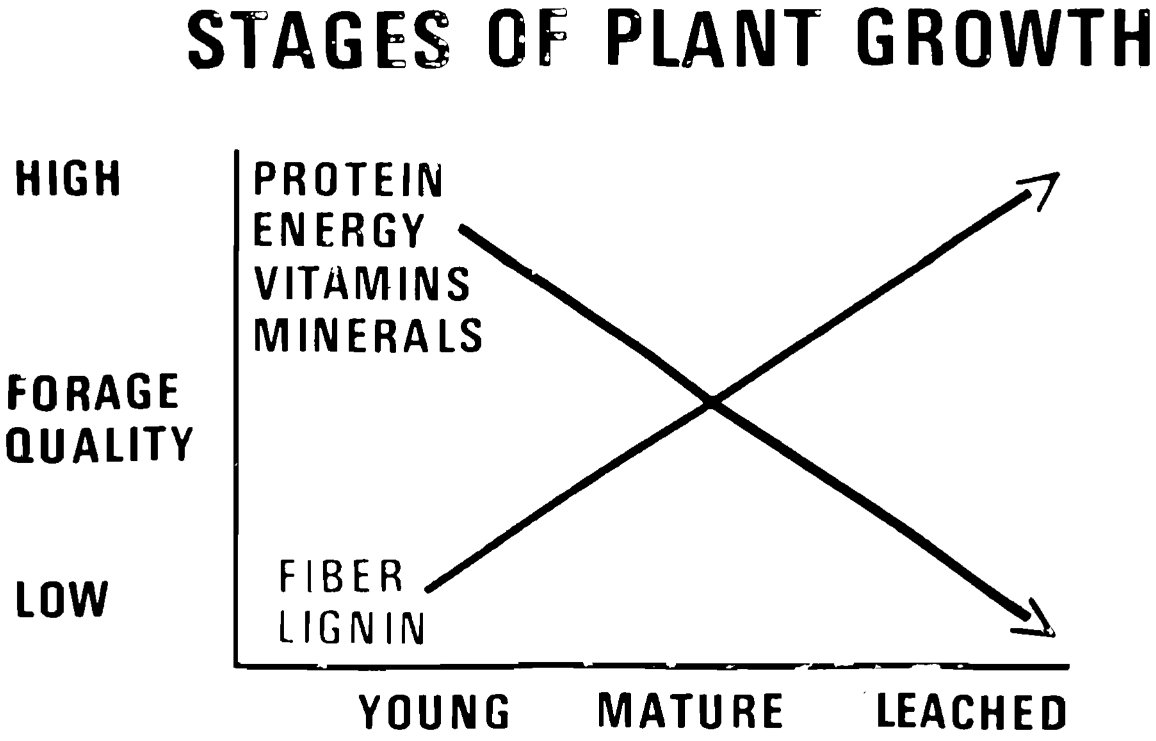

Figure 1. Seasonal trend of forage nutrients.

Table 1. Nutrient composition (%) of selected range plants at different stages of growth sampled on the San Joaquin Experimental Range (Gordon & Sampson, 1939).

GROWTH STAGE OF PLANT	DATE COLLECTED	LOCATION	TOTAL ASH	SILICA ASH	SILICA FREE ASH	Ca	P	K	CRUDE PROTEIN	CRUDE FIBER
SOFT CHESS (<u>BROMUS MOLLIS</u>)										
Leaves mostly dry, seed mature	1935 May 20	Field plot	7.45	3.87	3.58	.248	.388	1.30	7.63	28.74
Aerial growth dry, some seeds cast	1935 Aug 1	Field plot	6.49	3.19	3.30	.207	.254	1.38	4.49	35.25
Early leaf stage	1936 Feb 8	Field plot	14.28	2.14	12.14	.856	.488	4.62	22.50	24.60
Early leaf stage	1936 Mar 6	Field plot	12.67	2.48	9.53	.658	.52	4.48	20.21	27.14
Just before flowering	1936 Apr 3	Field plot	1.95	2.56	8.39	.499	.56	3.70	16.23	26.91
In full bloom	1936 Apr 3	Field plot	7.85	2.17	5.68	.351	.422	1.99	12.02	--
Seeds in dough stage	1936 May 8	Field plot	6.91	3.32	3.50	.274	.291	1.41	8.78	27.56
Dry, seeds mature, none cast	1936 May 8	Field plot	6.18	2.64	3.54	.275	.271	1.35	7.63	29.00
Dry, some seeds cast	1936 Jun 13	Field plot	6.09	2.63	3.46	.221	.24	1.33	6.10	31.44
Dry & weathered, most seeds cast	1936 Sep 10	Field plot	5.73	2.74	2.99	.241	.164	.96	3.76	38.32
Early leaf stage	1936 Mar 6	Nursery plot	10.21	2.39	7.82	.48	.277	3.95	23.58	--
Just before flowering	1936 Apr 3	Nursery plot	11.97	4.97	7.00	.327	.356	3.21	14.61	22.11
Seeds in dough stage	1936 May 8	Nursery plot	9.52	4.62	4.90	.182	.26	1.91	7.12	33.90
Dry, seed mature, none cast	1936 Jun 13	Nursery plot	9.44	6.09	3.35	.157	.179	1.30	6.36	31.57
Dry, weathered, most seeds cast	1936 Sep 10	Nursery plot	8.62	5.47	3.15	.165	.068	1.45	2.11	41.88
Weathered, some seeds cast	1936 May 10	Headquarters	7.02	3.33	3.69	.26	.34	.92	11.77	19.29
Early leaf stage	1937 Jan 23	Field plot	12.8	--	--	.672	.51	4.01	18.18	--
Early blooming stage	1937 Apr 8	Field plot	9.83	3.22	6.10	.365	.484	2.70	13.92	30.08
Seeds in dough stage	1937 May 9	Field plot	5.70	2.38	3.32	.241	.25	1.19	7.73	28.10
Dry, some seeds cast	1937 Jun 14	Field plot	5.54	2.28	3.26	.246	.284	1.31	6.25	31.32
Seed heads only, mature	1937 May 19	Field plot	6.29	2.74	3.55	.242	.401	1.00	12.53	17.23
Straw only, heads clipped	1937 Sep 18	Field plot	4.91	1.55	3.36	.179	.19	1.72	1.26	42.55
RIPGUT BROME (<u>BROMUS DIANDRUS</u>)										
Early leaf stage	1934 Dec 11	Field plot	--	--	--	.918	.577	5.99	23.54	20.84
Just before flowering	1935 Feb 9	Field plot	9.10	3.00	6.10	.353	.502	2.95	15.02	29.53
Nearly dry, seeds mature, none cast	1935 May 20	Field plot	5.87	2.28	3.59	.314	.24	1.43	6.99	25.64
Dry, seeds intact	1935 Aug 1	Field plot	5.63	2.50	3.13	.284	.23	1.34	3.73	33.04
Just before flowering	1936 Apr 3	Field plot	10.60	2.50	8.10	.549	.509	3.56	14.80	26.95
Dry, seeds mature, none cast	1936 May 8	Field plot	5.67	2.25	3.42	.314	.287	1.25	5.56	28.61
Dry, seeds intact	1936 Jun 13	Field plot	5.33	2.15	3.18	.315	.207	1.29	3.87	34.55
Early leaf stage	1937 Jan 23	Field plot	12.84	2.65	10.90	.922	.46	4.49	23.90	18.69
Early leaf stage	1937 Mar 4	Field plot	13.99	2.62	11.37	801	.513	4.69	27.26	23.56
Just before flowering	1937 Apr 8	Field plot	8.14	1.75	6.39	.505	.365	2.90	13.34	28.30
Leaves mostly dry, seeds mature	1937 May 19	Field plot	4.99	2.01	2.98	.301	.279	1.16	5.19	28.19
Dry, some seeds cast	1937 Jun 14	Field plot	5.53	2.45	3.08	.278	.193	1.26	3.92	32.42
Early leaf stage (matured)	1937 Jan 23	Headquarters	14.80	1.88	12.92	.416	.67	5.68	34.50	14.90
Seed heads only	1937 Jun 14	Field plot	4.05	1.14	2.91	.224	.299	.86	11.14	17.65
Seeds only, hulled	1937 Jun 16	Field plot	2.97	.32	2.65	.135	.338	.85	10.68	6.14

Table 1. (continued)

GROWTH STAGE OF PLANT	DATE COLLECTED	LOCATION	TOTAL ASH	SILICA ASH	SILICA FREE ASH	Ca	P	K	CRUDE PROTEIN	CRUDE FIBER
RED BROME (<u>BROMUS RUBENS</u>)										
Green, seeds in dough stage	1935 Mar 28	Field plot	6.12	2.93	3.19	.267	.274	1.26	6.73	31.73
Dry, seeds intact	1935 May 20	Field plot	6.37	3.44	2.93	.294	.253	.90	6.62	30.31
Dry, few seeds cast	1935 Aug 1	Field plot	5.58	2.99	2.59	.282	.201	.84	5.38	33.40
Early flowering stage	1936 Feb 8	Field plot	8.74	2.82	5.92	.462	.36	2.58	12.30	29.11
Seeds in dough stage	1936 Mar 6	Field plot	7.95	3.29	4.66	.327	.325	1.68	7.92	33.26
Dry, seds mature, none cast	1936 Apr 3	Field plot	7.18	3.06	4.12	.309	.293	1.40	7.89	31.79
Dry, seeds mature, none cast	1936 May 8	Field plot	6.81	3.39	3.42	.287	.224	1.30	7.62	28.31
Weathered, seeds mature, none cast	1936 Jun 13	Field plot	6.63	3.85	2.78	.27	.194	1.05	7.08	29.84
Early leaf stage	1936 Mar 6	Nursery plot	10.66	3.33	7.33	.569	.238	2.90	26.63	--
In full bloom	1936 Apr 3	Nursery plot	10.19	3.58	6.61	.317	.321	2.74	15.96	26.78
Seeds in dough stage	1936 May 8	Nursery plot	6.35	3.23	3.12	.224	.164	1.55	7.49	33.14
Leaves mostly dry, seeds mature	1936 May 8	Nursery plot	.04	4.23	2.81	.179	.156	1.12	6.32	31.77
Dry, seeds mature, none cast	1936 Jun 13	Nursery plot	6.22	3.77	2.45	.156	.122	1.17	4.93	37.75
Weathered, some seeds cast	1936 Sep 10	Nursery plot	.03	2.94	3.09	.182	.05	1.32	2.97	41.65
Seeds mature, none cast	1937 Apr 8	Field plot	7.82	4.54	3.28	.416	.272	1.17	6.47	32.20
Dry, seeds mature, none cast	1937 May 19	Field plot	5.52	2.43	3.09	.247	.23	1.12	6.38	28.39
Dry, seeds intact	1937 Jun 14	Field plot	6.18	3.23	2.90	.21	.22	1.04	6.34	31.30
Seed heads and upper stems only	1936 Jun 13	Field plot	7.44	4.56	2.88	.284	.198	.99	8.21	27.13
Seeds only	1937 Aug 1	Field plot	6.45	3.85	2.60	.181	.283	.93	9.94	22.77
Seeds only	1937 Jun 14	Field plot	6.25	--	--	.203	.403	.84	9.14	18.12
ANNUAL FESCUE (<u>FESTUCA MEGALURA</u>)										
Early leaf stage	1934 Dec 11	Field plot	--	--	--	--	--	--	19.60	19.27
Just before flowering	1935 Feb 10	Field plot	8.38	3.46	4.92	.373	.439	1.93	13.87	--
In full bloom	1935 Mar 28	Field plot	5.26	2.24	3.02	.279	.269	1.10	7.49	33.16
Dry, seeds mature	1935 May 20	Field plot	6.24	3.46	2.78	.283	.259	.78	.55	3.16
Dry, some seeds cast	1935 Aug 1	Field plot	5.72	3.22	2.50	.257	.264	.77	4.26	36.00
Early leaf stage	1936 Feb 8	Field plot	9.73	3.06	6.67	.577	.405	2.64	15.30	22.63
Just before flowering	1936 Mar 6	Field plot	8.91	3.70	5.21	.477	.39	2.05	1.28	29.45
Dry, seeds mature	1936 Apr 3	Field plot	6.24	2.56	3.68	.348	.279	1.01	8.65	32.20
Dry, some seeds cast	1936 May 8	Field plot	5.27	2.76	2.51	.33	.219	.77	6.49	32.97
Dry, most seeds cast	1936 June 13	Field plot	3.87	2.18	1.69	.24	.113	.62	2.20	42.41
Early leaf stage	1936 Mar 6	Nursery plot	9.85	4.52	5.33	.418	.292	2.28	20.63	--
Just before flowering	1936 Apr 3	Nursery plot	8.75	3.82	4.93	.294	.27	2.02	14.03	27.10
Leaves mostly dry, seeds mature	1936 May 8	Nursery plot	6.70	3.88	2.82	.295	.215	.94	5.83	32.48
Dry, seeds intact	1936 Jun 13	Nursery plot	6.88	4.13	2.75	.298	.139	.92	6.66	34.62
Weathered, seeds cast	1936 Sep 10	Nursery plot	6.70	4.78	1.94	.263	.056	.90	2.39	41.47
Early leaf stage	1937 Jan 23	Headquarters	9.46	4.06	5.40	.462	.33	2.26	16.53	16.61
Just before flowering	1937 Mar 4	Headquarters	10.24	4.19	6.05	.319	.427	2.39	14.59	24.06
In full bloom	1937 Apr 8	Field plot	5.94	2.99	2.95	.297	.322	1.08	7.61	32.96
Dry, seeds mature, few cast	1937 May 19	Field plot	6.20	3.49	2.71	.278	.25	.94	6.33	32.42
Dry, most seeds cast	1937 Jun 14	Field plot	6.36	3.20	3.16	.224	.183	1.30	2.59	40.64
Seeds only	1935 Aug 1	Field plot	5.59	3.15	2.44	.228	.444	.53	13.16	20.08
Seeds only	1935 Aug 1	Field plot	5.75	3.24	2.51	.239	.301	.53	13.20	19.96
Seeds only	1937 Jun 14	Field plot	5.15	2.46	2.69	.22	.296	.67	12.36	17.48

Table 1. (continued)

GROWTH STAGE OF PLANT	DATE COLLECTED	LOCATION	TOTAL ASH	SILICA ASH	SILICA FREE ASH	Ca	P	K	CRUDE PROTEIN	CRUDE FIBER
BROADLEAF FILAREE (ERODIUM BOTRYS)										
Dry, seeds mature	1934 Aug 8	Field plot	12.67	.62	12.05	1.811	.141	2.88	7.06	--
Early leaf stage	1934 Dec 11	Field plot	18.98	--	--	1.905	.663	5.08	30.24	11.63
Early leaf stage	1935 Feb 9	Field plot	11.63	.05	11.58	1.433	.622	4.09	30.46	16.07
Seeds mostly mature	1935 Mar 28	Field plot	7.38	.15	7.23	1.301	.384	1.81	8.17	25.55
Partly dry, some seeds cast	1935 May 20	Field plot	11.69	.27	11.42	2.588	.166	2.43	5.69	28.92
Dry, all seeds cast	1935 Aug 1	Field plot	12.13	.73	11.40	2.507	.168	2.64	4.61	29.32
Early leaf stage	1935 Dec 21	Field plot	15.01	1.10	13.91	1.793	.404	4.29	26.70	10.94
Early leaf stage	1936 Feb 8	Field plot	13.35	.18	13.17	1.844	.38	3.77	23.30	12.20
In full bloom	1936 Mar 6	Field plot	11.76	.13	11.63	1.839	.492	3.48	18.66	16.90
Green, seeds mature	1936 Apr 3	Field plot	7.93	.20	7.73	1.298	.336	1.80	10.22	6.80
Dry, seeds cast	1936 May 8	Field plot	11.27	.97	10.30	2.169	.18	2.39	4.84	28.52
Dry and weathered	1936 Jun 13	Field plot	10.87	1.03	9.84	2.444	.169	1.70	3.36	28.70
Green, seeds mature, none cast	1936 Apr 3	Headquarters	7.83	.16	7.67	1.401	.233	1.91	7.68	22.40
Mostly green, full seed stage	1936 May 8	Nursery plot	12.79	.68	12.11	2.904	.114	2.00	7.89	24.70
Early leaf stage	1937 Jan 23	Field plot	11.32	.20	11.12	1.852	.394	3.27	19.94	8.86
In full bloom	1937 Mar 4	Field plot	11.50	.60	10.90	1.793	.448	3.00	15.11	10.97
Dry, seeds cast	1937 May 19	Field plot	10.93	.84	10.09	2.126	.313	2.67	4.17	26.51
In full bloom	1937 Mar 4	Headquarters	10.67	.57	10.10	1.443	.452	3.31	16.96	12.35
Mostly green, few seeds cast	1937 Apr 8	Headquarters	8.77	.27	8.50	1.587	.411	2.21	6.69	29.10
Seeds, whole including beak	1935 Aug 1	Headquarters	4.09	.14	3.95	.798	.295	.64	8.75	--
Seeds, minus beak	1935 Aug 1	Headquarters	9.14	.19	8.95	1.339	1.54	1.43	29.99	18.15
Seeds, beak only	1935 Aug 1	Headquarters	2.77	.14	2.63	.548	.059	.69	1.85	44.14

Table 2. Nutrient composition (%) of subterranean clover at the U.C. Hopland Field Station in 1985 (Jones, 1985).

Date Collected	Protein	P	S	K	Ca	Mg
February	20.1	.25	.17	2.77	.75	.33
March	17.6	.23	.14	2.31	.75	.31
April	15.1	.23	.12	2.22	.73	.33

Table 3. Protein content (%) of rose and subterranean clover from late spring through the dry season at the U.C. Sierra Foothill Range Field Station (Kay, 1970).

Date Collected	Rose Clover	Subterranean Clover
April 29	14.8	13.4
June 1	10.8	10.9
June 30	11.6	11.8
Sept. 6	11.0	10.1
Nov. 1	10.0	10.2

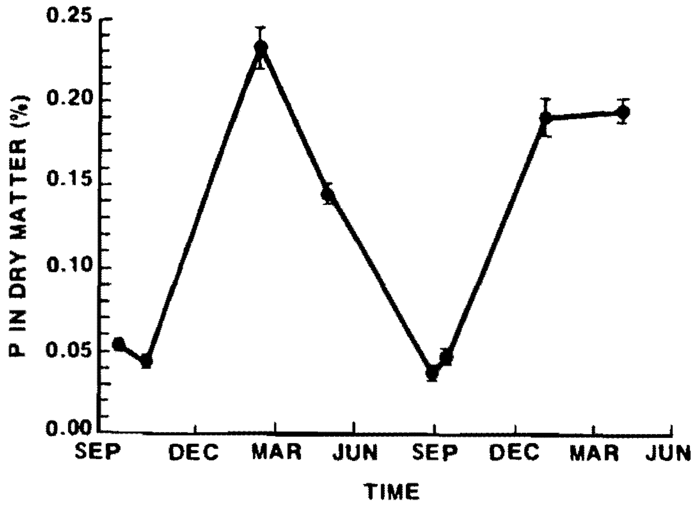

Figure 2. Seasonal changes in phosphorus content (%) of range forage.

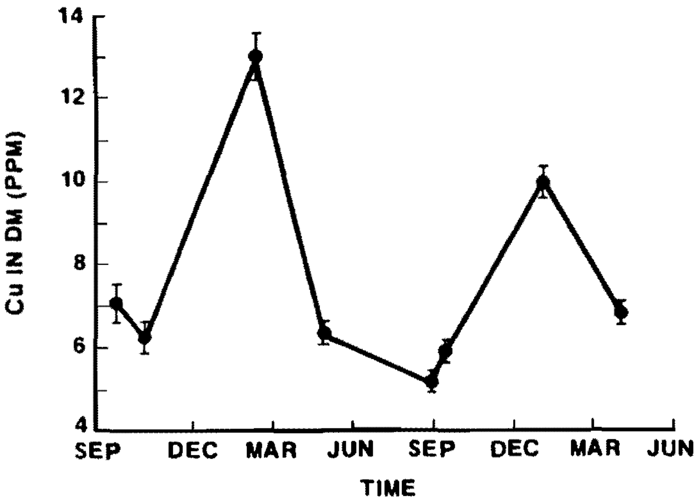

Figure 3. Seasonal changes in copper content (ppm) of range forage.

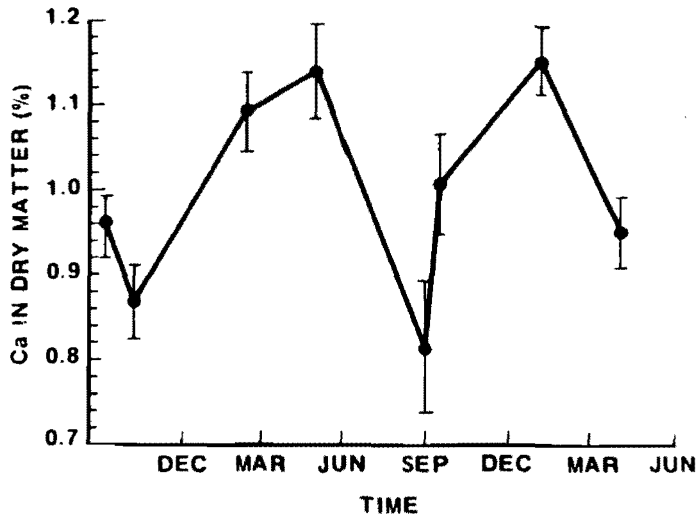

Figure 4. Seasonal changes in calcium content (%) of range forage.

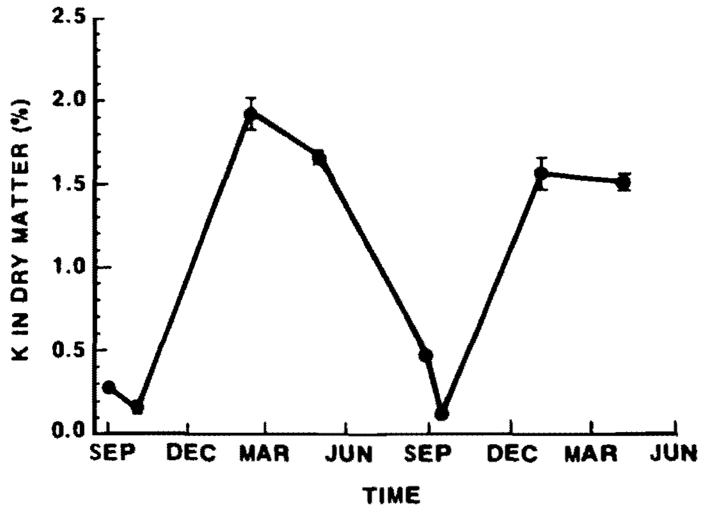

Figure 5. Seasonal changes in potassium content (%) of range forage.

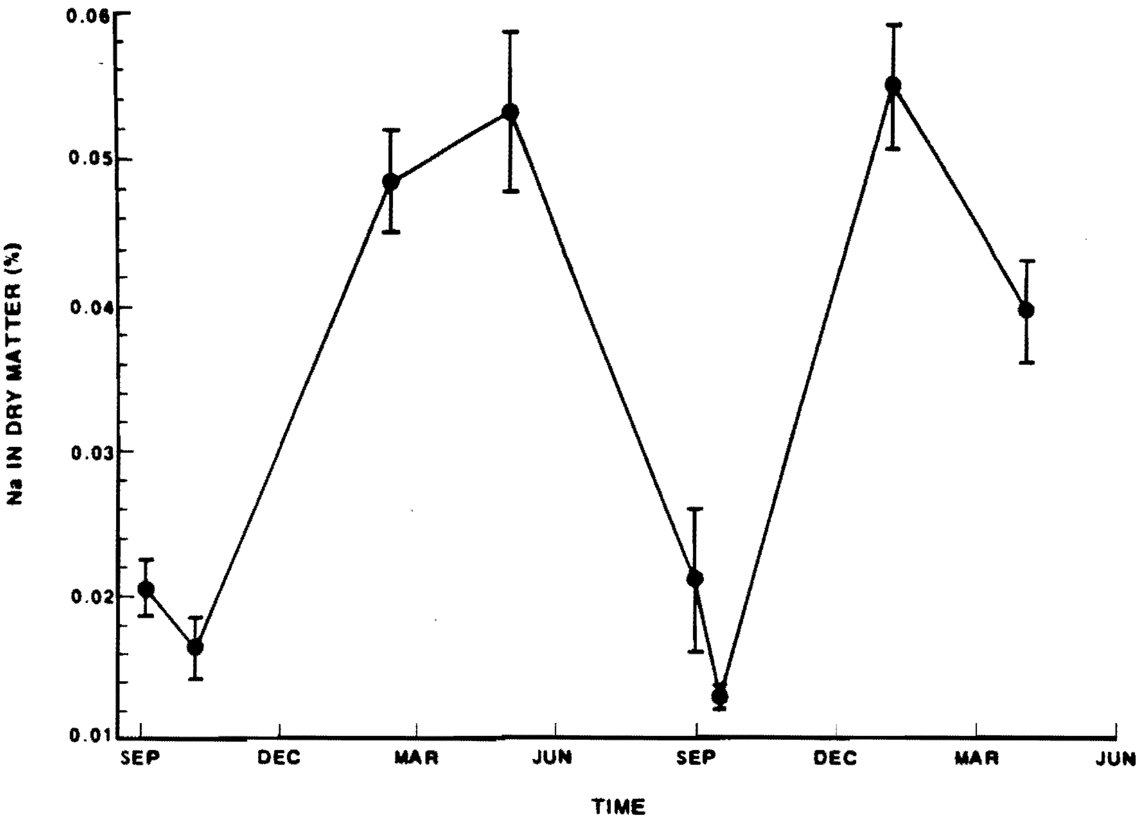

Figure 6. Seasonal changes in sodium content (%) of range forage.

Weather Influences

The new fall growing season begins when rains start germination of stored seed (George et al. 1985). Cattle grazing this forage may lose weight, thus the term inadequate green forage (Bentley and Talbot 1951) (Figure 7). The onset and length of this period of inadequate green forage is dependent on prevailing weather conditions. If the fall and winter period is dry or cold then green feed production will be poor and range supplementation may be necessary to maintain cattle performance. If warm weather coincides with adequate precipitation, then forage production will be greater and animal performance will improve. Dry residual forage from the previous growing season is commonly available for grazing and provides energy but is low in protein and other vital nutrients. Leaching due to precipitation further decreases the nutritional quality of dry residue. The inadequate green forage may contain adequate energy, protein, phosphorus and vitamin A on a dry matter basis, but because of high forage water content livestock are unable to consume adequate forage to meet their need for these nutrients.

Rapid spring growth commences with warming conditions in late winter or early spring (Figure 8). This is also the period when animal performance improves. This period is commonly called the rapid spring growth or adequate green forage season. This forage is usually nutritionally adequate for growth, maintenance and gestation. Rapid spring growth continues for a short time until soil moisture is exhausted. Peak standing crop occurs at the point where soil moisture limits growth or when plants are mature. This period is followed by the summer dry season when the forage is a fair energy source but is low in protein, phosphorus, carotene and other important nutrients (Figure 9). Livestock performance during this period may be poor without supplementation. During this summer period it is common practice to provide supplements, transport the livestock to high elevation green feed or to use irrigated pasture.

Diet Selection and Intake

For a plant to have value it must be selected and grazed by stock, and it must contribute substantially to the digestible nutrients of the diet. Figure 10 shows the seasonal variation in species composition in the diet of beef cows during a below-average rainfall year at the San Joaquin Experimental Range. During the summer and fall cow diets were dominated by dry forage. With the onset of fall rains the proportion of dry residue (leached dry forage) in the diet declined and green forage increased. The top of the chart shows that the winter was drier than normal but storms were rather uniformly distributed. The dry forages at the start of the 12 month period were produced in the extremely wet preceeding year. It is suggested that the low rainfall produced a forage crop low in legumes and rushes.

Selectivity by grazing animals is important in determining value of the plant species on a particular range. The range species composition has a great bearing on the forage value obtained from it.

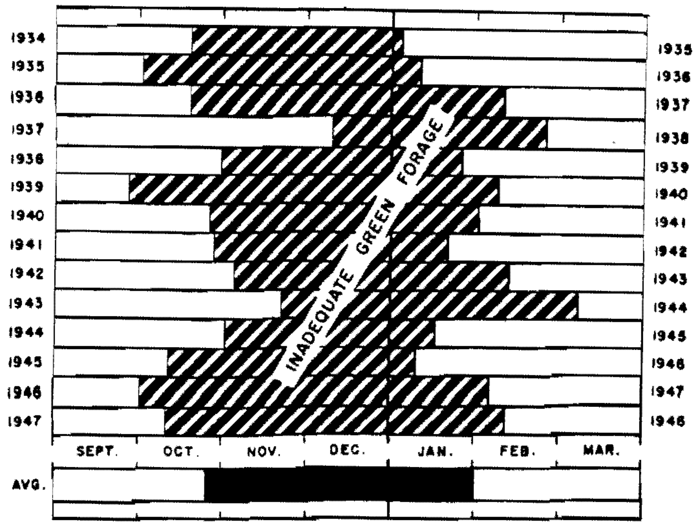

Figure 7. Variations in length of time that green forage was inadequate on foothill range at the San Joaquin Experimental Range.

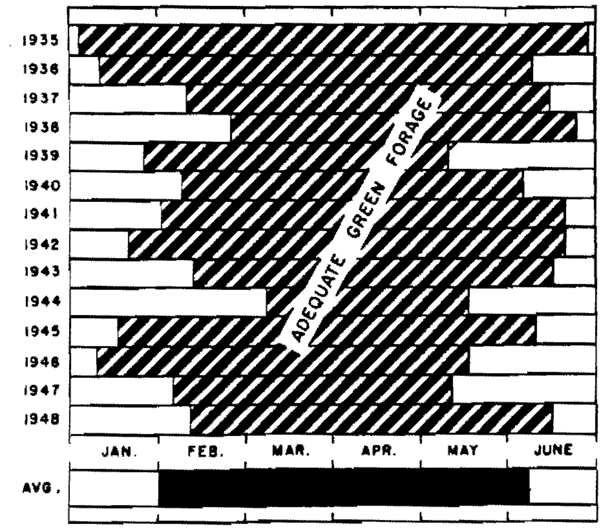

Figure 8. Variations in length of time that green forage was adequate on foothill range at the San Joaquin Experimental Range.

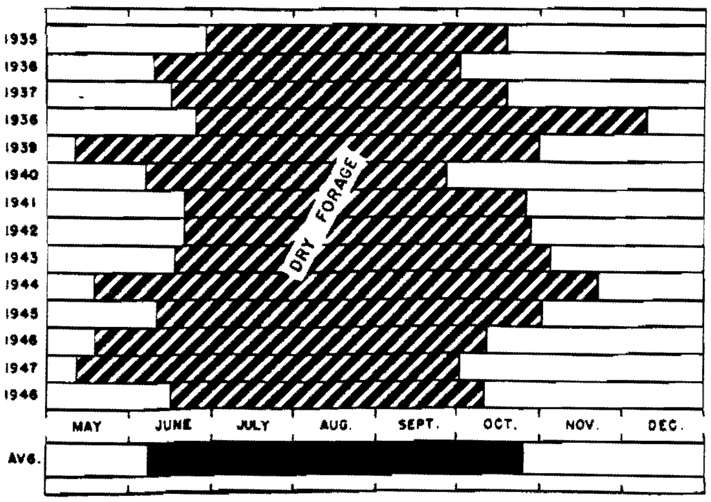

Figure 9. Variations in the length of time that cattle grazed almost entirely on dry forage on foothill range at the San Joaquin Experimental Range.

Organic matter intake (Figure 11) and digestibility (Figure 12), was greatest in April and early May in a Sierra Foothill Range Field Station study (Morris 1985, Morris and Delmas, 1980). Protein consumed by fistulated steers (Figure 13) was greatest in March (Morris and Delmas, 1980). Each of these indicators of forage quality measured at the U.C. Sierra Foothill Range Field Station near Marysville, California reached their peak during the period of rapid spring growth described above. Likewise each of these indicators reached its minimum during the summer or fall dry season.

Unpalatable plants do not necessarily have poor nutritive value, but they are rendered of low value because they generally are not selected. It is possible to minimize the effects of selective grazing by forcing uniform use during particular seasons, but the animals may not perform quite as well. Where grazing is not forced stock will select the most palatable plants first.

Cattle tend to select diets that are higher in protein and lower in fiber than that contained on the average in the available forage. Protein in the diet can become limiting before energy, especially for young stock and lactating cows. This is one of the main reasons why performance of these classes of cattle declines sharply when the forage matures (Raguse et al. 1985). As plants mature selectivity may increase.

For optimum production the animal must be able to consume enough quality forage to meet its nutrient requirements. Forage intake is especially important early in the plant's growth period because the high moisture in young forage can limit total dry matter intake.

As the green forage season progresses the quality of forage species diverges due to differing rates of maturity. As more species mature forage quality declines rapidly and becomes limiting. As this occurs the manager has the option of moving stock to areas of less mature forage, supplementing, or modifying the demand by weaning the calves or taking off yearlings. Often, forage value differences may occur within a fairly short geographical distance. For example, species mature later on cool slopes and at higher elevations or in moister swales. Grazing these areas at later dates is commonly done to extend the season of acceptable forage value.

Digestive Physiology

The ruminant can survive, grow, and reproduce on forage alone because of the bacteria, protozoa, fungi and other microbes in the reticulo-rumen section of the digestive tract. During microbial fermentation volatile fatty acids, ammonia, methane and carbon dioxide are released and energy is liberated for growth of the microbial populations. Then the microbes are swept out of the rumen to the abomasum and small intestine with fluid and feed particles and may furnish nutrients needed by the ruminant animal. Ruminal bacteria can use various sources of nitrogen, primarily ammonia, amino acids and peptides, along with energy and minerals for growth. Limited amounts of non-protein nitrogen sources such as urea, are commonly fed to ruminant animals in range supplements.

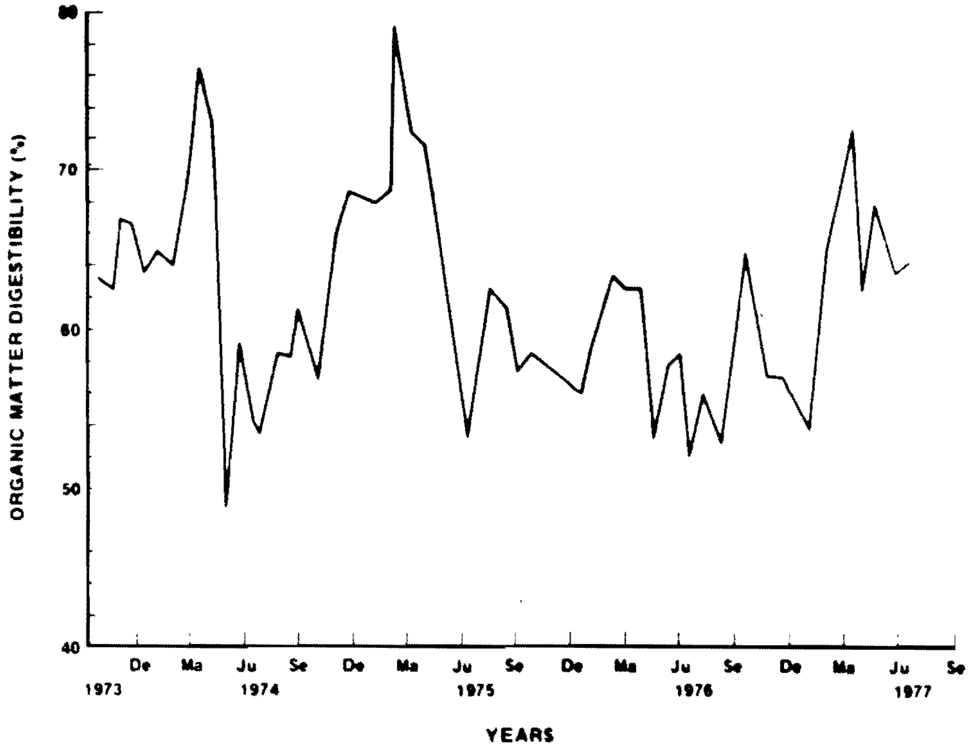

Figure 12. Seasonal variation in organic matter digestibility (%) of range forage samples collected by esophageal fistulated steers.

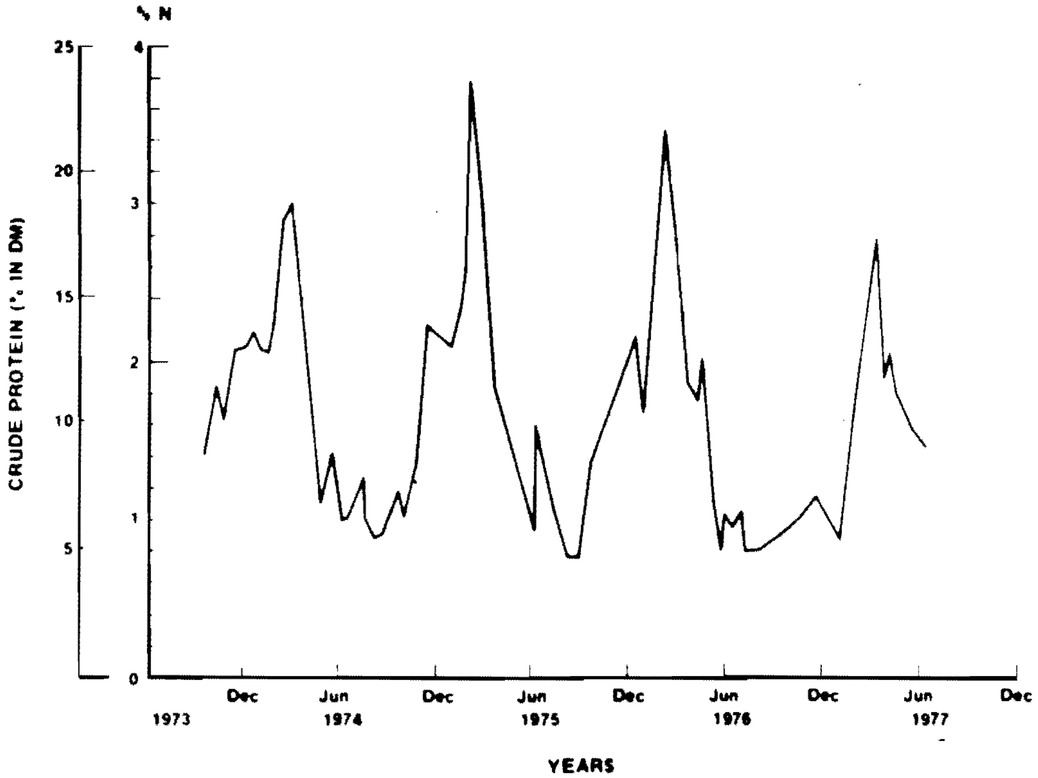

Figure 13. Seasonal variation in nitrogen (%) and crude protein (%) in range forage samples collected by esophageal fistulated steers.

STAGES OF PRODUCTION

The beef cow's stage of production should be one of the major criteria in planning a cow herd nutrition program. There are various ways of looking at the stage of production, but one of the best ways is to consider the 365-day beef-cow year, starting with calving and ending with the production of the next calf, Figure 14.

Time of Calving

Fall calving is a common practice on California's annual rangelands because of mild winters with available green forage. Spring calving is commonly practiced in regions of more severe winter weather.

The major factors related to the feasibility of fall or spring calving are:

1. Weather conditions
2. Availability and nutritive value of the forage and the use of supplemental feed
3. Labor
4. Capital inputs
5. Calf crop percentage
6. Relative weights of calves produced in the different calving seasons
7. Foothill abortion which affects cows 3-6 months pregnant during April 15 - June 1.

Figures 15 and 16 illustrate fall and spring calving and the variations in the periods of adequate green forage, deficient dry forage and the possible need for supplementation.

Rebreeding and Cow Condition

Cows must rebreed within 80-85 days after calving if a 365 day calving interval is to be maintained. Cow condition at the time of calving is an important factor determining how quickly a cow returns to estrus following calving. By monitoring the body condition of their cows, cattle producers can adjust feeding levels to insure an adequate rebreeding rate.

The importance of condition at calving time and cow rebreeding performance is illustrated in Table 4. Experience and research have shown that cows need to be in condition class six or seven to consistantly rebreed at 90% or better. Lusby (1983) discusses the condition scoring system. The system classifies cows from 1 (very thin) to 9 (very fat). Condition classes 6 and 7 indicate animals with a good smooth appearance or in very good flesh.

Period 1 (45 days)

This is the period after calving when the cow is lactating at her highest level to meet the demand of rapid calf growth. In addition, she must undergo uterine involution in preparation for the next pregnancy. She must also start recycling in order to produce a calf in

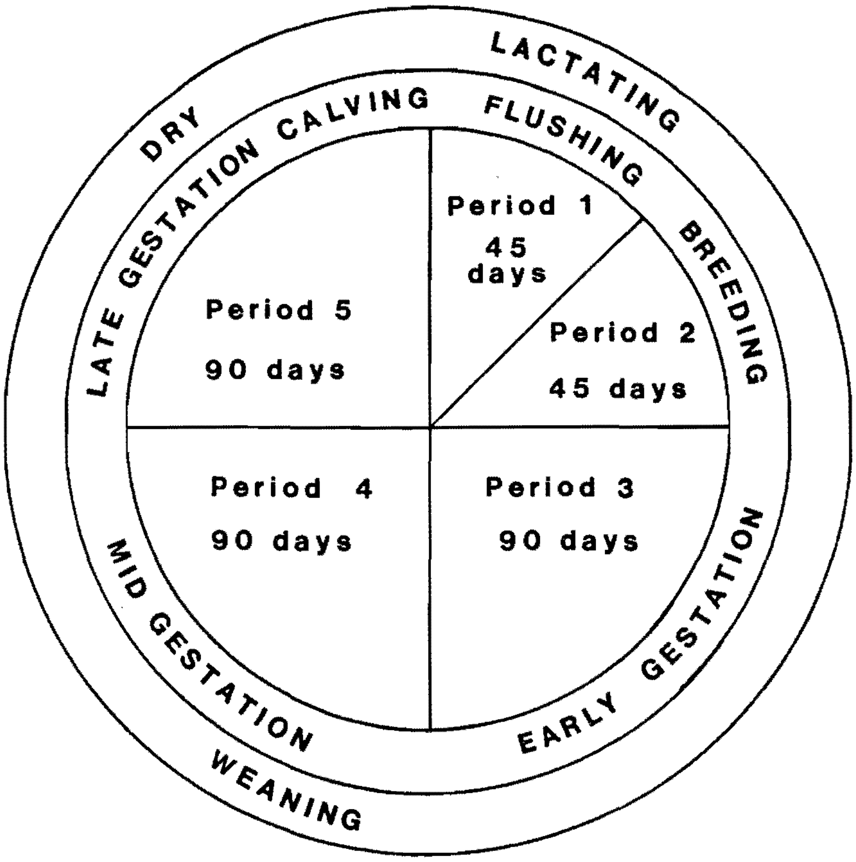

Figure 14. The beef cow reproduction calendar.

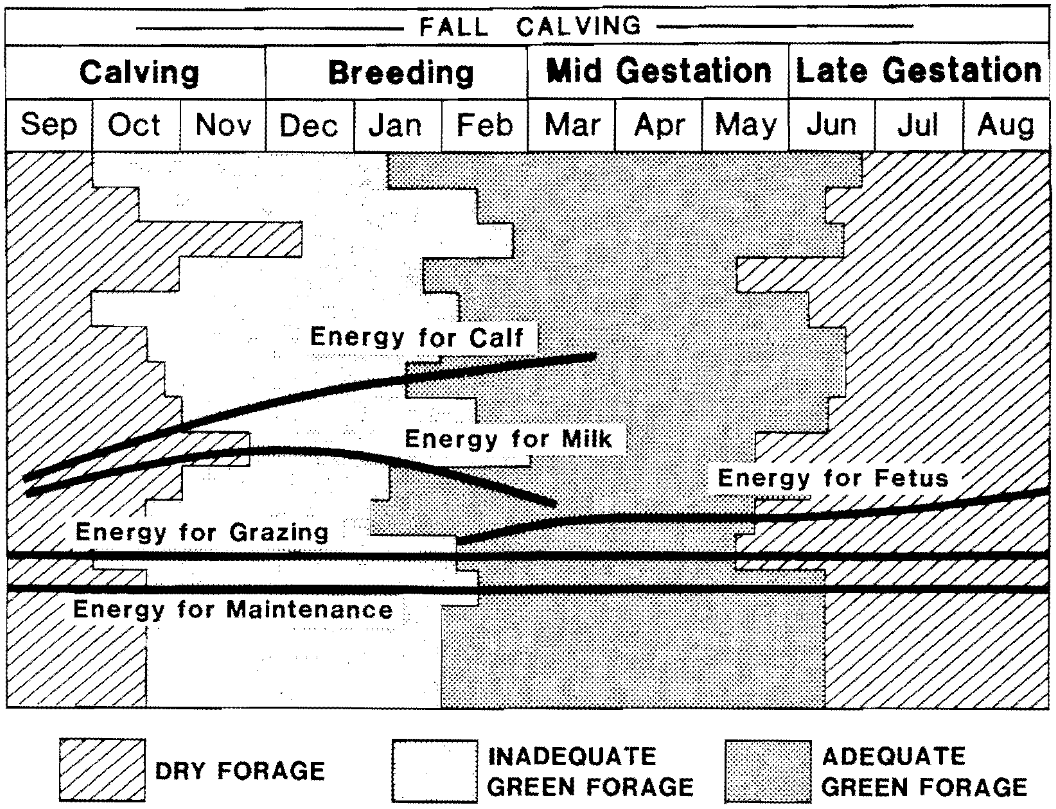

Figure 15. Fall calving calendar of livestock operations, energy requirements and seasonal variation in forage.

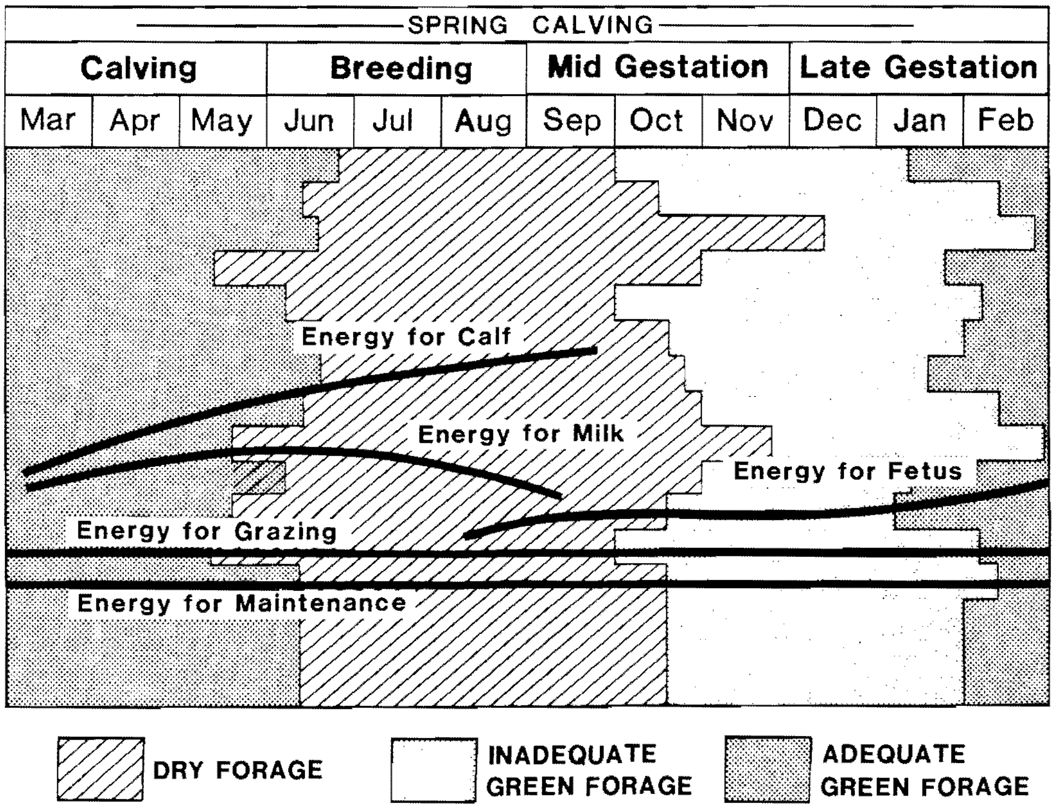

Figure 16. Spring calving calendar of livestock operations, energy requirements and seasonal variation in forage.

Table 4. Cow condition and rebreeding (Lusby 1983).

	Condition Score 4	5	6	7
No. cows	25	59	80	23
Pregnant 1st 20 days (%)	4	15	36	65
Pregnant 1st 60 days (%)	24	51	69	87

Table 5. Effects of feed level on cow and calf performance (Corah et al. 1975).

	Level of energy 30 days precalving	
	Low	High
TDN	4.6	10.6
Birth weight of calves	58.7	67.0
Calf liveability:		
Birth	90.5	100.0
Weaning	71.4	100.0
Percent calves treated for scours	52.0	33.4
Cow's milk production	9.1	12.4
Calf weaning weight	294.4	320.1
Percent of cows in estrus by 40 days post calving	37.5	47.6

Table 6. Nutrient Requirements for a 1000-Pound Beef Cow (NRC, 1984).

	Period 1 (Calving)	2 (Breeding)	3 (Early Gest)	Gestation Mid	Late
Dry Matter, lbs	20.6	21.0	19.5	18.1	19.6
Protein, lbs/day	2.5	2.6	2.0	1.3	1.6
TDN, lbs	13.8	14.0	11.5	8.8	10.5
Ca, g/day	36	38	25	15	23
P, g/day	25	27	20	15	18
Vit. A (1000's IU)	37	38	36	25	31

12 months. Flushing at this time will help to bring the cow in heat and prepare the uterus for the new embryo. It will also help insure an adequate milk supply for optimum calf growth.

Period 2 (45 days)

In this period the cow should rebreed. In a fall calving situation with cows out on range or pasture and lactating during adverse winter months, risk of inadequate nutrition is great. Energy requirements during Periods 1 and 2 are fairly high, and adequate protein, minerals, and vitamins are especially important because of the high level of milk production. During Periods 1 and 2 cows require 112 percent more protein, 36 percent more energy, and 124 percent more calcium and phosphorus than during gestation. If the cow is poorly fed during Periods 1 and 2, it can affect: milk production, calf growth, estrus, conception rate, pregnancy, and loss of weight. To the beef cow and cattleman, Periods 1 and 2 are the most important nutritional periods.

Period 3 (90 days)

During this 90-day period the cow should be in early pregnancy while still lactating and maintaining a calf. If the cow is poorly fed during the period, it will primarily affect her milk production level and her suckling calf's growth rate.

Period 4 (90 days)

This period includes the time immediately before and after weaning the calf. During this time the beef cow's main function is to maintain her developing fetus. The beef cow's nutritional needs at this time are the lowest level in the cycle. During this period, some low quality forages such as straw or crop residues can be used to good advantage to lower feed cost provided they are properly supplemented.

Period 5 (90 days)

This is the third most important period of the cow's year because during it 70 to 80 percent of the fetal growth occurs. In addition, the cow should be gaining weight in preparation for the coming lactation period. This last 90 days before calving is a period when a cattleman can do an awful lot to insure proper calf birth weight, liveability, and growth rate (Table 5).

NUTRIENT REQUIREMENTS

One of the main factors in planning a cow herd supplementation program is the cow's nutritional requirements, and a critical factor that influences these requirements is the stage of production. Listed in Table 6 are the estimated requirements for a 1000 pound beef cow in each of the five periods. The nutrients which should be considered as potentially deficient in annual grasslands of California are energy, protein, phosphorus, magnesium, sodium chloride, certain trace minerals and vitamin A.

Energy

Energy, often measured as total digestible nutrients (TDN), Net Energy for maintenance (NEm), Net Energy for gain (NEg), Digestible Energy (DE), or Metabolizable Energy (ME), is the most important nutritional factor to consider for beef cows for several reasons. It is the nutritional factor most commonly lacking due to the shortage of forage. Were it not for energy, the nutrient requirements of the beef cow could be met by 2-4 pounds of total feed per day. Insufficient

energy intake may occur when cattle are forced to graze deficient dry forage in the fall (inadequate green season).

SYMPTOMS OF ENERGY DEFICIENCY

- Retarded growth
- Delayed sexual maturity
- Poor conception rate
- Shortened lactation period
- Decline in milk yield
- Loss of body weight
- Failure to conceive
- Lowered resistance to disease and parasites
- Increased mortality (toxic plants)
- May be complicated by protein, mineral and/or vitamin deficiency

Protein

Protein is the nutrient most likely to be lacking in summer and fall diets when dry forage is plentiful but green forage is not adequate. Supplemental protein for wintering cows is usually the largest cash expense in the yearly costs of maintaining a cow. Supplements such as cottonseed and safflower oil meal are primary sources. Urea is a non-protein compound which ruminants may convert to protein with varying degrees of efficiency through the action of micro-organisms in the rumen. The use of liquid supplements and blocks has increased drastically over the past few years and will continue to increase as research provides information on efficient formulations including urea. Presently, urea has a low to moderate value for cattle on dry range when it replaces protein in a natural protein supplement. Proper management procedures are important when urea is fed to prevent ammonia toxicity and to enhance urea utilization.

SYMPTOMS OF PROTEIN DEFICIENCY
Reduced appetite
Reduced growth rate (fetus and calf)
Loss of weight
Inadequate intake of other nutrients
Delayed heat
Irregular heat
Poor conception rate
Reduced milk production

Calcium

Calcium is usually not a serious problem in most beef cow diets. It is seldom deficient in California range forage.

SYMPTOMS OF CALCIUM DEFICIENCY
Poor Growth
Depletion of calcium
Swollen, tender joints
Arched back
Stiffness
Deformed legs
Fractures

Phosphorus

Phosphorus may be borderline to definitely deficient in range cow diets during summer, fall and winter periods in California. When high protein and liquid supplements are fed, they usually supply adequate phosphorus to supplement native forage.

SYMPTOMS OF PHOSPHORUS DEFICIENCY
Decreased appetite
Chewing wood, bones and hair
Low blood phosphorus
Stiff joints and lameness
Decreased milk production
Failure to show heat
Poor conception rates

Salt

Salt should always be provided free choice in loose pack or block form. Placing salt away from water is a common practice for improving stock distribution and achieving better range utilization.

SYMPTOMS OF SALT DEFICIENCY
Licking and chewing various objects
Loss of appetite
Unthrifty appearance
Rough hair coat
Decreased milk production
Reduced gains
Lack of coordination
Weakness
Death

Magnesium

Under California conditions grass tetany or hypomagnesemic tetany often occurs. It is a major problem especially in lactating cows grazing lush rapidly growing patures highly fertilized with nitrogen during cool foggy seasons. Grass tetany can be prevented by providing 8 grams of magnesium per head per day.

Trace Minerals

Deficiencies of trace minerals such as copper, iodine and selenium exist in many areas of California. It may be desirable to provide a trace mineralized salt mix as a precautionary measure if there is any reason to suspect a deficiency. Selenium deficiencies are concentrated in northern (especially northeastern) California. Selenium can be administered as an injection or as a pellet placed in the reticulum. Selenium provided in supplement blocks has generally not proved effective.

SYMPTOMS OF SELENIUM DEFICIENCY
White muscle disease
Retained placentas
Reduced gains
Unthriftiness
Diarrhea

Vitamin A

Vitamin A deficiencies in beef cow herds occur in California. A cow stores up several months supply in her liver during the adequate

green feed period, but this supply can be rapidly depleted in a lactating cow. Vitamin A deficienies may also occur in fall calves during dry years or in young cows.

SYMPTOMS OF VITAMIN A DEFICIENCY
Watery eyes
Night blindness
Scouring
Respiratory infection
Poor conception
Abortion - shortened gestation period
Birth of dead, weak or blind calves
Retained placentas
Uncoordinated calves
Poor conception rate

Supplemental vitamin A should be provided by:

1. Adding it to a protein supplement
2. Injecting it intramuscularly (one million international units will last 3 months);
3. Adding it to a mineral mix.

Potassium

Generally, forages contain more potassium than required by beef cows. However, potassium concentration decreases with advancing maturity of forage and can be reduced further by leaching. Potassium deficiency results in decreased feed intake, decreased milk yield, reduced weight gain and muscular weakness.

RANGE SUPPLEMENTATION

Supplementation means making up the difference in quality between what range forage provides and what cattle need. Supplementation does not mean substituting purchased feed for range forage. A supplement should be designed and fed to enhance the utilization of the total diet. Successful supplementation requires the producer to know what nutrients are deficient, the degree of deficiency and the economics of alternative supplemental feeds.

COW HERD SUPPLEMENTATION - POINTS TO CONSIDER
Maximum use of forage
Forage availability
Stage of production
Physical condition
Nutrients supplied
Cost of nutrients
Availability
Form
Ease, cost and convenience
Palatability and acceptance
Breed
Weather
Specific nutrient deficiency

It has been demonstrated that small amounts of supplement, usually protein, can enhance utilization and animal performance on low quality forage. Table 7 shows the effect of protein supplements on heifer weights while eating grass hay or grazing dry range. In the first experiment, weight gain increased as the level of protein increased, as would be expected. But, in the second experiment, 1 lb. of 40% protein supplement gave performance equal to 2 lbs. of 20% protein feed. This effect usually holds true whenever there are adequate quantities of low quality forage.

Frequency of Supplementation

Contrary to some opinions, cattle do not require daily supplementation. Table 8 summarizes the effect of feeding cattle daily, three times per week, and bi-weekly. This data shows that it makes no difference whether the supplement is fed at a given rate each day, tri-weekly, or bi-weekly. Even if the cows are not fed daily, they should be observed as often as necessary, especially during the pre and post-calving season. Similar results were found in a Nebraska study, where heifer calves were fed a daily allowance of Alfalfa Hay (4 lbs), at daily, weekly or bi-weekly intervals (Table 9).

Cow Life Span

Due to the high cost and time interval rquired to develop a replacement heifer and place her into production, a maximum life span of the beef female is of great economic importance. Limited research suggests that once a beef female meets her needs for optimum growth and reproduction, to feed her in excess of this need may be detrimental. A shortage of feed could also prove to be a liability (Table 10).

Table 7. Weight changes for heifers fed protein supplements and grass hay or grazing range (Lusby 1983).

Supplement Weight and Protein (%)	Heifer Weight Change (lbs)
Grass Hay	
1 lb. - 20 %	- 11
1 lb. - 30 %	+ 34
1 lb. - 40 %	+ 81
Range	
1 lb. - 20 %	- 26
1 lb. - 40 %	+ 15
2 lb. - 20 %	+ 15
2 lb. - 40 %	+ 38

Table 8. Effect of feeding intervals on range beef cows fed cottonseed meal (Neumann 1977).

Frequency of Feeding	Daily	Tri-weekly	Bi-weekly
Winter Gain (lb.)			
Year 1	91	88	38
Year 2	-60	-62	-37
Year 3	-80	-121	-98
Year 4	-167	-176	-170
Calf Crop Weaned (%)	81	89	86
Calf Weight Cow/ Steer Equivalent (lbs)	367	399	374

Table 9. Effect of feeding alfalfa hay to heifer calves at intervals (Neumann 1977).

	Feeding intervals		
	Daily	Bi-weekly	Weekly
Winter Gain (lbs)	59	62	76
Summer gain (lbs)	272	248	250
TOTAL Gain (lbs)	331	310	326

Table 10. Levels of feeding and lifetime performance of beef cows (Pope 1967).

	Supplement/Head		
	1 lb. CSM	2-1/2 lb. CSM	2-1/2 lb. CSM 3 lb. Oats
No. of heifer calves started on test, 1948	30	30	30
Average cow-years on test	12.7	11.6	10.7
No. of cows removed for:			
-Failure to wean calf 2 successive years	6	9	9
-Cancer eye	1	4	5
-Spoiled udder	2	1	4
-Disease	0	1	2
-Accidental death	1	0	0
-Died at calving	0	0	1
-Crippled	1	2	1
-Foreign objects	1	0	2
-Unknown	2	2	1
TOTAL	14	19	25
Average mature body weight, lbs.	1142	1147	1194
Reproductive Performance:			
Average birth-weight, lb.	77.6	77.6	78.8
Average weaning weight, lb.	479	482	483
Percent calf crop weaned	90.3	83.9	83.8

Forms of Supplements

Dry roughages, alfalfa, grass or grain hay can be used but should be analyzed to determine nutritive value. Qualilty hays properly supplemented often result in a satisfactory supplemental feeding program.

Dry supplements may be furnished as meals, blocks or cubes. Blocks and cubes have the advantage that they may be fed on the ground whereas meals require the use of a feeder. Intake of meals can be successfully controlled by the use of salt. Hardness has also been used successfully to limit supplement intake.

Molasses or other feed by-products such as corn steep liquor or ammoniated whey are the principle ingredients of liquid supplements. Liquid supplements are easily handled and dispensed by liquid feed companies.

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