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Low Cost Cow/Calf Program: The School – Part XI

In this installment we will cover the last section (# 14) of the notebook from Dr. Diven's "Low cost cow/calf program: The school" titled "Samples, Labs, Feed Stores".

Forage Sampling

As Dr. Diven indicated in his notebook for the school "analyses of forage samples must indicate the nutrients cattle are eating". What he points out is that it does no good to just sample plants you are interested in or sampling from just a square or round area as is done to estimate plant biomass. He also suggests that whole plant sampling should not be done but what should be sampled is what the animals are eating. Prior to sampling the range forage you need to watch the cattle as they graze to determine what they are eating – that is, what plants and what parts of those plants. If your cattle are grazing rangeland forage year round it is suggested to sample once a month for at least a year but preferably for three years. For those that do not graze their cattle on range during the winter/early spring months they should sample the hay and/or silage that are to be fed.

If you have questions about sampling range forage for quality analysis feel free to contact me. I've had a fair amount of experience in doing this so should be able to give you some pointers.

The nutrients to have your forage(s) analyzed for as suggested by Dr. Diven are Crude Protein, ADF (Acid Detergent Fiber), ADICP (Acid Detergent Insoluble Crude Protein), NDF (Neutral Detergent Fiber), NDICP (Neutral Detergent Insoluble Crude Protein), Lignin, Ether Extract (Fat), Ash, Calcium (Ca), Phosphorus (P), Magnesium (Mg), Potassium (K), Sodium (Na), Iron (Fe), Zinc (Zn), Copper (Cu), Manganese (Mn), Molybdenum (Mo), and Sulfur (S). He also suggested that analysis be conducted for Cobalt (Co), Iodine (I), and Selenium (Se), at least the first year, of spring growth-summer maturity forages and any hay that is to be fed (every year if from different sources).

This is quite a laundry list but are all these nutrients actually needed to be analyzed for? Probably not; so what should be? Of the minerals all, however, if Mo is low to non-existent in the first year samples it would not need to be analyzed for thereafter. Some labs do not include Mo in their mineral package and some do not include S although they will analyze for them for an additional fee. Please note that there can be quite a range in charges for forage quality analyses among labs so it would be wise to shop around for the best prices. I found one lab that included Co in their mineral package but otherwise it along with I and Se are not included and have to be requested separately and for additional fees.

Crude Protein and ADF would be the bare minimum to have your forages analyzed for. For hay it might be advisable to have it analyzed for ADICP if excessive heating is suspected. Excessive heating of hay (put up too wet) can result in some of the crude protein being rendered unavailable (insoluble). If the amount of insoluble crude protein is greater than 12% this needs to be account for in the formulation of a ration. Up to 12% of crude protein in forages is insoluble but has been taken into account when determining protein needs for animals (Schroeder, J.W. 2010).

Following is an example of finding the % of crude protein in hay that is insoluble and the % that is available (ACP):

Crude Protein = 7.0%; ADICP = 1.1%
% insoluble = 1.1 ÷ 7.0 = 15.7%

% ACP = [CP% x (100 – (insoluble% – 12%))] ÷ 100

% ACP = [7.0 x (100 – (15.7 – 12.0))] ÷ 100
[7.0 x (100 – 3.7)] ÷ 100
[7.0 x 96.3] ÷ 100
674 ÷ 100 = 6.74%

In balancing a ration with this hay the 6.74% crude protein value would be used instead of the 7.0% value.

Dr. Diven indicated in his school notebook that the lab cannot say if the available protein is degradable or is escape but that you need to apply the 80% degradable and 20% escape amounts to the lab crude protein value. There are laboratory procedures to determine the degradable portion of crude protein but not all labs offer this analysis and it is an additional expense. The Feed Library (NRC 2000) lists the percent of crude protein that is degradable for forages and feeds so that can be used as a guideline. You can use Dr. Diven's 80% DIP amount [actually 72% - see Part IV (May 2010) of this series for explanation] but mature, dormant forage contains less DIP compared to fresh, leafy forage. In addition, the crude protein content of cool-season grasses besides being higher compared to that of warm-season grasses is also more degradable. A study estimating the degradable portion of crude protein in warm- and cool-season forages in northern Arkansas found that 73% of the protein in cool-season forages was degradable whereas it was only 61% in warm-season forages (Coblentz, et al., 2005). Thus, if your range pastures are dominated by cool-season grasses the 72% suggested by Dr. Diven may very well be sufficient but if they are dominated by warm-season grasses it might be better to use 61%. It might also be wise to reduce the degradable amounts to 63% and 53% for winter range cool- and warm-season grasses, respectively.

For determination of forage Net Energy maintenance (NEm) content Dr. Diven used an equation developed by Dr. William Weiss of Ohio State University to estimate forage Total Digestible Nutrient (TDN) content which was then used to estimate NEm. However, it is a daunting formula that requires the following analyses: crude protein, NDF, NDICP, ADICP, lignin, fat (ether extract), and ash. Many labs have a basic forage analysis package that includes these analyses and will do the calculations needed to estimate the forage's NEm content. Cost for the package is fairly reasonable if the lab uses Near Infra-Red Spectroscopy (NIRS) instead of wet chemistry. If the forage is alfalfa hay, corn silage, or an improved pasture grass such as smooth brome there is no issue using NIRS but for rangeland grasses it is better to have them analyzed with wet chemistry as NIRS has not been calibrated for most rangeland grasses. However, cost for all the needed analyses with wet chemistry can be three times as much as for NIRS. Thus another formula to estimate TDN content using just ADF analysis would be desirable.
Using Feed Library values for grasses the below equation (NRC 1984?) using just ADF analysis to estimate %TDN resulted in similar ($\pm$5%) NEm values as the Weiss equation.

%TDN = 96.35 – (%ADF x 1.15)

Thus analyzing rangeland forage for ADF and crude protein instead of all the other analyses needed to use the Weiss equation would save a significant amount of money. Although having the best estimate for NEm, especially when it is below the needs of the cow, is important a calculated value within 5% of that is probably sufficient.

As noted above, labs will calculate TDN and NEm but will not indicate what equations they used. If the amount of TDN reported is different from that obtained with the above equation using the lower amount, especially if NEm content is below the needs of the cow, may be warranted. However, on very low quality forages (see the example in the SOLUTIONS segment below) it might be best to use the lab's value as the NRC calculated value will probably be too low.

To compare the NEm content calculated by the lab with the amount obtained by using the TDN value from ADF analysis the following calculations need to be performed:

DE (Digestible Energy) = TDN x 0.02
ME (Metabolizable Energy) = DE x 0.82
Or ME = TDN x 0.0164 (0.02 x 0.82)

NEm = -0.50803 + (1.37 x ME) – (0.3042 x ME^2) + (0.051033 x ME^3)

<u>Example</u>
Forage ADF = 41%

%TDN = 96.35 – (41 x 1.15)
96.35 – 47.15 = 49.2%

ME (Mcal/lb) = 49.2 x 0.0164 = 0.807

NEm (Mcal/lb) = -0.50803 + (1.37 x 0.807) – (0.3042 x 0.807^2) + (0.051033 x 0.807^3)

-0.50803 + 1.106 – (0.3042 x 0.651) + (0.051033 x 0.526)

0.598 – 0.198 + 0.027 = 0.43 Mcal/lb

Note: The lower the ADF content the higher the NEm content. Thus forage with an ADF content of 30% will have a NEm content of 0.62 Mcal/lb whereas forage with an ADF content of 50% will have a NEm content of 0.25 Mcal/lb.

For those that attended one of Dr. Diven's Low cost cow/calf program schools you will find another equation for calculating %TDN *from %ADF followed by an equation to estimate NEm (Mcal/lb) on the first page of the Samples, Labs, Feed Stores section. The equation to estimate TDN is actually for estimating Digestible Dry Matter (DDM) and the following equation to estimate NEm is actually for Net Energy $_{Lactation}$ (NE_L). NE_L is used by the Dairy Industry but not for Beef cattle. In addition, the calculated NE_L values from %DDM appear to be higher than what they probably are so should not be used.*

The Feed Store

Dr. Diven points out in this segment that supplement manufacturers prefer that you purchase one of their standard products and will be reluctant to manufacture a supplement formulated by you or an out-side nutritionists for various reasons but primarily due to the micro minerals required. You will need to work with the company's nutritionist to overcome this problem. As we have already seen many of the macro minerals contain quantities of some of the micro minerals and thus through proper selection of them some of the trace minerals can be accounted for.

You can provide the supplement company your formula in the form of what ingredients you want and in what quantities but be prepared for the company to have to make substitutions. Due to this possibility it would be best to find out beforehand what ingredients the company has available before you make up your formula.

Another way to order a supplement is by specifying the nutrients needed and in what amounts. The company's nutritionist can then formulate a supplement based on the ingredients the company has available or access to. You need to know what the nutrient status of your existing forages and feeds are along with the requirements of your livestock.

SOLUTIONS

An example of formulating a supplement from the school notebook follows. Nutrient composition in Table 1a is from a laboratory analysis of a forage sample collected in eastern Oregon on 14 January 1993. The lab reported % amounts (Column A) are converted to the NEm basis (lb/Mcal) and the mg/kg (ppm) amounts are converted to mg/lb and listed in Column B of Table 1a. The equations used to convert the amounts are listed in Column C.

Table 1b lists the estimated physiological conditions of the beef cow, her daily forage and NEm consumption amounts, her energy and protein requirements, and the amounts of each nutrient needed in the supplement. The cow's dry matter forage consumption is based on percent of her shrunk body weight (SBW). The requirements for supplement section of Table 2 shows that the supplement needs to contain degradable protein, P, Mg, K, Na, S, Co, Cu, I, Se, and Zn. The amount needed in the supplement of each quality constituent is determined by subtracting the amount required by the amount consumed from the range forage.

For those of you that attended one of Dr. Diven's schools you may recall that he reported consumption of micro minerals on an mg/kg Mcal NEm basis as he did with protein and the macro minerals. Micro mineral content was divided by Mcal/lb NEm and the product multiplied by total Mcal NEm consumed to obtain the amount of the micro mineral ingested and reported as mg/kg (Mcal). However, as I pointed out in Part X (May 2012) of this series I believe this is an over-calculation of the amount consumed by a factor of 2.2. For example, if forage Cu content was 6 mg/kg and the cow consumed 9.8 kg (21.6 lb ÷ 2.2) of the forage she would consume 58.9 mg of Cu. However, if the method Dr. Diven promotes is used she would supposedly consume 129.2 mg/kg (Mcal) of Cu [(6 mg/kg ÷ 0.39Mcal/lb) * 8.4 Mcal/day]. I believe his error is not converting Mcal/lb to Mcal/kg.

From Table 1a the 0.39 Mcal of NEm per pound of dry forage is the same as 0.86 Mcal/kg (0.39 x 2.2); Dividing the 6 mg/kg of Cu by 0.86 Mcal/kg = 7.0 mg of Cu per Mcal of NEm; 7.0 mg/Mcal * 8.4 Mcal consumed = 58.7 mg Cu. Dividing 129.2 mg/kg (Mcal) by 2.2 yields 58.7 mg.

Dr. Diven also suggested that the amounts of each micro mineral the cow should consume be based on the total Mcal of NEm she ingests multiplied by a factor (as done with macro minerals). These amounts are also reported as mg/kg (Mcal) so need to be divided by 2.2 to come up with the correct mg/day the animal needs based on the Mcal of NEm she ingests.

Table 2 lists the ingredients used to formulate the supplement to address the shortfall in the range forage. Required amounts in Column A are from Column D of Table 1b. Although many of the listed ingredients contain other nutrients (Appendix Table 5) besides the one they are meant to address they are usually in such a small amount that they contribute little to the needed amounts and do not over supply those nutrients that are already sufficient.

For the Body Weight Change (Row 6, Table 1b) value the equations Dr. Diven provided from Buskirk, et al (1992) are used (Part III, Apr 2010) instead of the method from Simms (2009) introduced in Part VI (Jan 2011). The equations are not that difficult and actually may be less complicated to use. The importance of this value is that as the cow gains are losses weight her requirements change. That will be shown in the next installment of this series covering the annual nutrient needs of a Feb-Mar calving cow herd and the formulation of the supplement(s) to meet those needs.

On pages 9 – 11 is another example but in this case the solutions are not provided. You are invited to develop a supplement from the provided information. If you want send me your results and I will check your work. I will also furnish you with what I came up with for a supplement. If you have a computer with a spreadsheet program such as Excel you can enter the column information from Tables 3a, 3b, and 4 and let the computer do the necessary calculations. Appendix Tables 1 – 5 contain information to assist you in doing this exercise.

Note: In the formulating a supplement example in which Dr. Diven furnished the ingredients to be used he chose urea as the degradable protein supplement. He did this to simplify the process as urea contains only N that is 100% degradable. The protein in other protein supplements is usually not 100% degradable and they may contain other nutrients, especially NEm that has to be accounted for. If you decide to use a protein supplement that contains NEm remember that some of its DIP will need to be used by the rumen microbes to utilize it. The remaining amount of DIP will then be available to address the shortfall in the range forage.

In the Next Issue

We will work through an example similar to what was done in Part X (May 2012) but put it all together and take into account the information from this issue with regard to formulating a custom supplement package. The above two examples are for determining the needed supplements for a point in time but we know forage quality changes over the course of a year as well as the cow's physiological conditions and thus her nutrient requirements.

Table 1a. Forage analysis for an eastern Oregon forage sampled on 14 January 1993.

	Laboratory Report				Converted to NEm Basis, or lb/lb, or mg/lb			
		Columns	A				B	C
Row	**Units**	**Component**	**Amount**		**Units**	**Component**	**Amount**	**Equation**
1	Mcal/lb	NEm[1]	0.39		Mcal/lb	NEm	0.39	*From A1*
2	%	Crude Protein	3.4		lb/Mcal	Crude Protein	0.0872	*A2 ÷ 100 ÷ B1*
3	%	ADF	49.7		lb/Mcal	Degradable[2]	0.0550	*B2 x 0.63*
4	%	NDF	72.2		lb/Mcal	Escape	0.0174	*B2 x 0.20*
5	%	Calcium	0.28		lb/Mcal	Calcium	0.0072	*A5 ÷ 100 ÷ B1*
6	%	Phosphorus	0.05		lb/Mcal	Phosphorus	0.0013	*A6 ÷ 100 ÷ B1*
7	%	Magnesium	0.06		lb/Mcal	Magnesium	0.0015	*A7 ÷ 100 ÷ B1*
8	%	Potassium	0.18		lb/Mcal	Potassium	0.0046	*A8 ÷ 100 ÷ B1*
9	%	Sodium	0.013		lb/Mcal	Sodium	0.0003	*A9 ÷ 100 ÷ B1*
10	%	Sulfur	0.051		lb/lb	Sulfur	0.0005	*A10 ÷ 100*
11	mg/kg	Colbalt			mg/lb	Colbalt		*A11 ÷ 2.2*
12	mg/kg	Copper	6		mg/lb	Copper	2.73	*A12 ÷ 2.2*
13	mg/kg	Iodine			mg/lb	Iodine		*A13 ÷ 2.2*
14	mg/kg	Iron	1500		mg/lb	Iron	682	*A14 ÷ 2.2*
15	mg/kg	Manganese	42		mg/lb	Manganese	19.1	*A15 ÷ 2.2*
16	mg/kg	Molybdenum	2.2		mg/lb	Molybdenum	1.0	*A16 ÷ 2.2*
17	mg/kg	Selenium			mg/lb	Selenium		*A17 ÷ 2.2*
18	mg/kg	Zinc	22		mg/lb	Zinc	10	*A18 ÷ 2.2*
19					Minimum	Cu:Mo = 4:1	2.7:1	*B12 ÷ B16*

[1]NEm: Based on the %ADF the NEm value was probably derived by equations for grass forages from Penn State University. If the NRC (1984) equation is used to calculate TDN the resultant NEm amount would be 0.26 Mcal/lb. This sample was apparently not analyzed for its ADICP, NDICP, ash, fat, and lignin contents but if book values (Feed Library) for winter range are used the NEm value using the Weiss equation to calculate TDN the resultant NEm value would be 0.36 Mcal/lb.

[2]The Degradable portion of crude protein can range from 63% (winter range) to 72% (growing grass) for cool-season grasses and 53% to 61% for warm-season grasses.

Table 1b. Estimated physiological conditions of a 1200 lb beef cow (SBW @ BCS 5.0), daily amounts of forage and NEm consumed, her energy and protein requirements, and the requirements for the supplement.

Estimated Physiological Conditions and Amount of Forage and NEm Consumed				
Row	**Columns**		**D**	**E**
1	Week in Gestation		22	
2	Month in Lactation			
3	Body Wt (EMBW in lb)		1333	
4	Body Condition Score		5.0	
5	Body Wt (EBW in lb)		1021	*((D4 – 7.85) x (0.082 x D3)) + D3 OR SBW x 0.851*
6	Body Weight Change (lb/day)		0.01	*If D15 ≤ 0, D15 ÷ (1.3665 + 0.33073 x D4)* *If D15 > 0, D15 ÷ {(1.3665 + 0.33073 x D4) x 2.95}*
7	Dry Forage Consumed (lb)		21.6	*SBW x 0.018 (Appendix Table 1 for %body weight factor)*
8	NEm Consumption (Mcal)		8.4	*D7 x B1*
Daily Requirements for Energy and Protein				
9	NEm(M)	Mcal	7.7	$D5^{0.75} \times 0.04256$
10	NEm(G)	Mcal	0.6	*80 lb birth weight (Appendix Table 2)*
11	NEm(L)	Mcal		
12	Protein(M)	lb	0.61	*D9 x 0.07895*
13	Protein(G)	lb	0.06	*D10 x 0.09615*
14	Protein(L)	lb		*D11 x 0.2362*
15	NEm net	Mcal	0.1	*D8 – (D9 + D10 +D11)*
Daily Requirements for Supplement				
16	NEm	Mcal		*If D15 is positive no need for additional energy*
17	Degradable Protein	lb	0.378	*(0.10 x D8) – (D8 x B3)*
18	Escape Protein	lb		*(D12 + D13 + D14) – (D8 x B4) – (0.10 x D8)*
19	Calcium	lb		*1.5 x (D8 x B6 + D20 if positive) – D8 x B5*
20	Phosphorus	lb	0.025	*(D9 x 0.00426 + D10 x 0.0048 + D11 x 0.00272) – (D8 x B6)*
21	Magnesium	lb	0.013	*D8 x 0.003 – D8 x B7*
22	Potassium	lb	0.096	*D8 x 0.016 – D8 x B8*
23	Sodium	lb	0.017	*D8 x 0.00227 – D8 x B9*
24	Sulfur	lb	0.022	*D7 x 0.0015 – D7 x B10*
25	Colbalt	mg	0.08	*(D8 x 0.02) ÷ 2.2 – D7 x B11*
26	Copper	mg	2.6	*(D8 x 16) ÷ 2.2 – D7 x B12* ***(Check Cu: Mo ratio)***
27	Iodine	mg	3.82	*(D8 x 1) ÷ 2.2 – D7 x B13*
28	Iron	mg		*(D8 x 100) ÷ 2.2 – D7 x B14*
29	Manganese	mg		*(D8 x 90) ÷ 2.2 – D7 x B15*
30	Molybdenum	mg		*No requirement for Mo*
31	Selenium	mg	1.53	*(D8 x 0.4) ÷ 2.2 – D7 x B17*
32	Zinc	mg	127.6	*(D8 x 90) ÷ 2.2 – D7 x B18*
33	Cu:Mo = 4:1 minimum		2.8:1	*((D8 x 16) ÷ 2.2) ÷ (D7 x B16)* ***(Need to increase Cu)***[1]

[1]Copper needs to be increased beyond the minimum amount needed to account for the amount of Molybdenum ingested. The total amount of Cu needed is 86.4 mg (21.6 mg Mo ingested x 4). The amount of Cu ingested from the forage is 59.0 mg (21.6 lb x 2.73 mg/lb), so a total of 27.4 mg needs to be provided (86.4 – 59.0).

Table 2. Nutrient requirements of a 1200 lb beef cow (SBW @ BCS 5.0) and ingredients and amounts used in the formulation of the supplement to meet her needs.

Row	Daily Requirements		Supplement Formulation					
	Column	A[3]		B				
	Nutrients		Ingredients		lb/day	How To Determine lb/day	Percent[4]	lb/ton[5]
1	NEm (Mcal)					*A1 ÷ B1*		
2	Degradable Protein (lb)	0.378	Urea	281.5%	0.1342806	*A2 ÷ (B2 ÷ 100)*	20.9374	418.749
3	Escape Protein (lb)					*A3 ÷ (B3 ÷ 100)*		
Macro-Minerals[1]								
4	Calcium (lb)					*A4 ÷ (B4 ÷ 100)*		
5	Phosphorus (lb)	0.025	Dicalcium Phosphate	19.3%	0.1295337	*A5 ÷ (B5 ÷ 100)*	20.1973	403.946
6	Magnesium (lb)	0.013	Magnesium Oxide	56.2%	0.0231217	*A6 ÷ (B6 ÷ 100)*	3.6068	72.135
7	Potassium (lb)	0.096	Potassium Chloride	50.0%	0.1920000	*A7 ÷ (B7 ÷ 100)*	29.9372	598.744
8	Sodium (lb)	0.017	Salt	39.34%	0.0432130	*A8 ÷ (B8 ÷ 100)*	6.7379	134.758
9	Sulfur (lb)	0.022	Calcium Sulfate	18.62%	0.1181525	*A9 ÷ (B9 ÷ 100)*	18.4227	368.454
Micro-Minerals[1, 2]								
10	Cobalt (mg)	0.80	Cobalt Carbonate	460000	0.0000038	*A10 ÷ (B10 ÷ 2.2)*	0.0006	0.012
11	Copper (mg)	27.4	Copper Sulfate	254500	0.0002369	*A11 ÷ (B11 ÷ 2.2)*	0.0369	0.739
12	Iodine (mg)	3.82	EDTA	803400	0.0000105	*A12 ÷ (B12 ÷ 2.2)*	0.0016	0.033
13	Iron (mg)					*A13 ÷ (B13 ÷ 2.2)*		
14	Manganese (mg)					*A14 ÷ (B14 ÷ 2.2)*		
15	Molybdenum (mg)							
16	Selenium (mg)	1.53	Sodium Selenite	456000	0.0000074	*A16 ÷ (B16 ÷ 2.2)*	0.0012	0.023
17	Zinc (mg)	127.6	Zinc Sulfate	363600	0.0007721	*A17 ÷ (B17 ÷ 2.2)*	0.1204	2.408
18	Cu: Mo = 4:1 minimum	4.0:1						
19				Total	0.6413421		100	2000

[1]Minerals: It is suggested to use carbohydrates or sulfates not oxides, except for Magnesium
[2]Values in Column B for micro-minerals are mg/kg (ppm), thus to convert to lb/day needed the amounts are divided by 2.2
[3]Column A: Values from Table 1b, Daily Requirement for Supplement section, Column D
[4]Percent values are determined by dividing the lb/day of each ingredient by the Total lb/day for the supplement
[5]lb/ton amounts are determined by multiplying the percent value for each ingredient by 2000 (lb in a ton) and then dividing by 100

Table 3a. Forage analysis of rangeland forage.

	Laboratory Report			Converted to NEm Basis, or lb/lb, or mg/lb			
		Columns	**A**			**B**	**C**
Row	**Units**	**Component**	**Amount**	**Units**	**Component**	**Amount**	**Equation**
1	Mcal/lb	NEm[1]	0.67	Mcal/lb	NEm		*From A1*
2	%	Crude Protein	22.9	lb/Mcal	Crude Protein		*A2 ÷ 100 ÷ B1*
3	%	ADF	26.5	lb/Mcal	Degradable[2]		*B2 x 0.72*
4	%	NDF	62.2	lb/Mcal	Escape		*B2 x 0.20*
5	%	Calcium	0.84	lb/Mcal	Calcium		*A5 ÷ 100 ÷ B1*
6	%	Phosphorus	0.40	lb/Mcal	Phosphorus		*A6 ÷ 100 ÷ B1*
7	%	Magnesium	0.41	lb/Mcal	Magnesium		*A7 ÷ 100 ÷ B1*
8	%	Potassium	3.27	lb/Mcal	Potassium		*A8 ÷ 100 ÷ B1*
9	%	Sodium	0.035	lb/Mcal	Sodium		*A9 ÷ 100 ÷ B1*
10	%	Sulfur	0.013	lb/lb	Sulfur		*A10 ÷ 100*
11	mg/kg	Colbalt		mg/lb	Colbalt		*A11 ÷ 2.2*
12	mg/kg	Copper	11	mg/lb	Copper		*A12 ÷ 2.2*
13	mg/kg	Iodine		mg/lb	Iodine		*A13 ÷ 2.2*
14	mg/kg	Iron	164	mg/lb	Iron		*A14 ÷ 2.2*
15	mg/kg	Manganese	50	mg/lb	Manganese		*A15 ÷ 2.2*
16	mg/kg	Molybdenum	1.3	mg/lb	Molybdenum		*A16 ÷ 2.2*
17	mg/kg	Selenium		mg/lb	Selenium		*A17 ÷ 2.2*
18	mg/kg	Zinc	33	mg/lb	Zinc		*A18 ÷ 2.2*
19				minimum	Cu:Mo = 4:1		*B12 ÷ B16*

[1]NEm: Based on the %ADF if the NRC (1984) equation was used to calculate TDN the resultant NEm value would be 0.68 Mcal/lb.

[2]The Degradable portion of crude protein can range from 63% (winter range) to 72% (growing grass) for cool-season grasses and 53% to 61% for warm-season grasses.

Table 3b. Estimated physiological conditions of a 1400 lb beef cow (SBW @ BCS 6.0), daily amounts of forage and NEm consumed, her energy and protein requirements, and the requirements for the supplement.

Estimated Physiological Conditions and Amount of Forage and NEm Consumed			
Row	**Columns**	**D**	**E**
1	Week in Gestation		
2	Month in Lactation	1	*Peak Milk – 17.5 lb/day*
3	Body Wt (EMBW in lb)	1405	
4	Body Condition Score	6.0	
5	Body Wt (EBW in lb)		*((D4 – 7.85) x (0.082 x D3)) + D3 OR SBW x 0.851*
6	Body Weight Change (lb/day)		*If D15 ≤ 0, D15 ÷ (1.3665 + 0.33073 x D4)* *If D15 > 0, D15 ÷ {(1.3665 + 0.33073 x D4) x 2.95}*
7	Dry Forage Consumed (lb)		*SBW x %body weight factor (Appendix Table 1)*
8	NEm Consumption (Mcal)		*D7 x B1*
Daily Requirements for Energy and Protein			
9	NEm(M) Mcal		*$D5^{0.75}$ x 0.04256*
10	NEm(G) Mcal		
11	NEm(L) Mcal		*Appendix Table 3*
12	Protein(M) lb		*D9 x 0.07895*
13	Protein(G) lb		*D10 x 0.09615*
14	Protein(L) lb		*D11 x 0.2362*
15	NEm net Mcal		*D8 – (D9 + D10 +D11)*
Daily Requirements for Supplement			
16	NEm Mcal		*If D15 is positive no need for additional energy*
17	Degradable Protein lb		*(0.10 x D8) – (D8 x B3)*
18	Escape Protein lb		*(D12 + D13 + D14) – (D8 x B4) – (0.10 x D8)*
19	Calcium lb		*1.5 x (D8 x B6 + D20 if positive) – D8 x B5*
20	Phosphorus lb		*(D9 x 0.00426 + D10 x 0.0048 + D11 x 0.00272) – (D8 x B6)*
21	Magnesium lb		*D8 x 0.003 – D8 x B7*
22	Potassium lb		*D8 x 0.016 – D8 x B8*
23	Sodium lb		*D8 x 0.00227 – D8 x B9*
24	Sulfur lb		*D7 x 0.0015 – D7 x B10*
25	Colbalt mg		*(D8 x 0.02) ÷ 2.2 – D7 x B11*
26	Copper mg		*(D8 x 16) ÷ 2.2 – D7 x B12* ***(Check Cu: Mo ratio)***
27	Iodine mg		*(D8 x 1) ÷ 2.2 – D7 x B13*
28	Iron mg		*(D8 x 100) ÷ 2.2 – D7 x B14*
29	Manganese mg		*(D8 x 90) ÷ 2.2 – D7 x B15*
30	Molybdenum mg		*No requirement for Mo*
31	Selenium mg		*(D8 x 0.4) ÷ 2.2 – D7 x B17*
32	Zinc mg		*(D8 x 90) ÷ 2.2 – D7 x B18*
33	Cu:Mo = 4:1 minimum		*((D8 x 16) ÷ 2.2) ÷ (D7 x B16)*

Table 4. Nutrient requirements of a 1400 lb beef cow (SBW @ BCS 6.0) and ingredients and amounts used in the formulation of the supplement to meet her needs (Appendix Table 5 for mineral supplements that can be used for the ingredients).

	Requirements		Supplement Formulation					
	Column	**A**		**B**				
Row	Nutrients		Ingredients		lb/day	How To Determine lb/day	Percent[1]	lb/ton[2]
1	NEm (Mcal)					*A1 ÷ B1*		
2	Degradable Protein (lb)					*A2 ÷ (B2 ÷ 100)*		
3	Escape Protein (lb)					*A3 ÷ (B3 ÷ 100)*		
4	Calcium (lb)					*A4 ÷ (B4 ÷ 100)*		
5	Phosphorus (lb)					*A5 ÷ (B5 ÷ 100)*		
6	Magnesium (lb)					*A6 ÷ (B6 ÷ 100)*		
7	Potassium (lb)					*A7 ÷ (B7 ÷ 100)*		
8	Sodium (lb)					*A8 ÷ (B8 ÷ 100)*		
9	Sulfur (lb)					*A9 ÷ (B9 ÷ 100)*		
10	Cobalt (mg)					*A10 ÷ (B10 ÷ 2.2)*		
11	Copper (mg)					*A11 ÷ (B11 ÷ 2.2)*		
12	Iodine (mg)					*A12 ÷ (B12 ÷ 2.2)*		
13	Iron (mg)					*A13 ÷ (B13 ÷ 2.2)*		
14	Manganese (mg)					*A14 ÷ (B14 ÷ 2.2)*		
15	Molybdenum (mg)							
16	Selenium (mg)					*A16 ÷ (B16 ÷ 2.2)*		
17	Zinc (mg)					*A17 ÷ (B17 ÷ 2.2)*		
18	Cu: Mo = 4:1 minimum							
19				Total				

[1]Percent values are determined by dividing the lb/day of each ingredient by the Total lb/day for the supplement
[2]lb/ton amounts are determined by multiplying the percent value for each ingredient by 2000 (lb in a ton)

Appendix Table 1: Percent of body weight to estimate forage dry matter intake of beef cows in different physiological stages and subjected to different supplementation programs. *(From Table 14-2, D.D. Simms, 2009)*

Forage Type[1]/Conditions	Dry, Gestating	Lactating
Low quality/unsupplemented	1.5	2.0
Low quality/protein supplemented	1.8	2.2
Low quality/energy supplemented	1.5	2.0
Average quality/unsupplemented	2.0	2.3
Average quality/protein supplemented	2.2	2.5
Average quality/energy supplemented	2.0	2.3
High quality	2.5	2.7

[1]Forage Type: Low quality – winter range, crop residues in winter, very low quality hay (e.g. mature bromegrass); Average quality – late summer/early fall range, good grass hay (e.g. late bloom brome), crop residues shortly after harvest; High quality – spring/early summer range, alfalfa hay and corn silage

Appendix Table 2: NEm requirements (Mcal/day) for the last five months of Gestation for calf birth weights of from 60 to 100 pounds.

	Calf Birth Weight (lb)								
Weeks (Mon) Pregnant	**60**	**65**	**70**	**75**	**80**	**85**	**90**	**95**	**100**
21-24 (5)	0.43	0.47	0.50	0.54	0.57	0.61	0.65	0.68	0.72
25-28 (6)	0.76	0.83	0.89	0.95	1.02	1.08	1.15	1.21	1.27
29-32 (7)	1.29	1.40	1.50	1.61	1.72	1.83	1.93	2.04	2.15
33-36 (8)	2.07	2.25	2.42	2.59	2.77	2.94	3.11	3.29	3.46
37-40 (9)	3.18	3.44	3.71	3.97	4.23	4.50	4.76	5.03	5.29

Appendix Table 3: Monthly milk production, NEm and net protein requirements for Lactation at three levels of peak milk production (lb/day @ week 9).

	Milk Production (lb/day)			NEm (L) Mcal/day)			Net Protein (lb/day)		
Month	**24.0 lb**	**17.5 lb**	**11.0 lb**	**24.0 lb**	**17.5 lb**	**11.0 lb**	**24.0 lb**	**17.5 lb**	**11.0 lb**
1	12.5	9.1	5.7	4.26	3.10	1.94	1.01	0.73	0.46
2	23.0	16.8	10.5	7.84	5.70	3.56	1.85	1.35	0.84
3	23.3	16.9	10.6	7.92	5.76	3.60	1.87	1.36	0.85
4	19.6	14.3	8.9	6.68	4.86	3.04	1.58	1.15	0.72
5	15.2	11.0	6.9	5.16	3.75	2.35	1.22	0.89	0.55
6	11.1	8.1	5.1	3.79	2.76	1.72	0.90	0.65	0.41
7	7.9	5.7	3.6	2.69	1.95	1.22	0.63	0.46	0.29
8	5.5	4.0	2.5	1.88	1.37	0.85	0.44	0.32	0.20

Appendix Table 4. Composition of some common highly degradable protein supplemental feeds on a 100% dry matter basis.

Feed Name	DM[1] (%)	NEm Mcal/lb	Protein (%)			Macro-Minerals (%)						Micro-Minerals (mg/kg)						
			Total	DIP[2]	UIP[3]	Ca	Mg	P	K	Na	S	Co	Cu	I	Fe	Mn	Se	Zn
Cottonseed meal	92	0.81	46.1	26.3	21.0	0.20	0.65	1.16	1.65	0.07	0.42	0.53	16		162	27	0.98	74
Canola meal	92	0.72	40.9	54.8	12.3	0.21	0.33	0.65	1.80	0.04	0.37	0.14	18		750	77		53
Soybean meal	89	0.94	50.0	32.5	17.5	0.40	0.31	0.71	2.22	0.04	0.46	.012	22		185	35	0.51	57
Sunflower meal	90	0.67	25.9	20.7	7.0	0.45	0.70	1.02	1.27	0.03	0.33		4		33	20	2.30	105
Urea	99		281.0	281.0														
Feather meal	90	0.71	85.8	25.7	58.3	1.19	0.06	0.68	0.20	0.24	1.85	0.13	14	0.05	702	12	0.98	105
Fish meal	90	0.79	67.9	27.2	40.7	5.46	0.16	3.14	0.77	0.44	0.58	0.12	11	1.19	594	40	2.34	157

[1]DM(%): As fed; if 1.0 lb of a feed is required on a dry matter basis 1.09 lb as is would need to be fed if it was 92% dry (1.0 ÷ 0.92)
[2]DIP: Degradable Intake Protein [3]UIP: Undegradable Intake Protein or Escape Protein

Appendix Table 5. Composition of some mineral feed supplements on a 100% dry matter basis.

	Macro-Minerals (%)						Micro-Minerals (mg/kg)						
Feed Name	Ca	Mg	P	K	Na	S	Co	Cu	I	Fe	Mn	Se	Zn
Ammonium Phosphate (Mono)	0.28	0.46	24.74	0.01	0.06	1.46	10	10		17400	400		100
Ammonium Sulfate						24.10		1		10	1		
Calcium Carbonate	39.39	0.05	0.04	0.06	0.06					300	300		
Calcium Sulfate, dihydrate	23.30					18.60							
Cobalt Carbonate						0.20	460000						
Copper Sulfate						12.80		254500					
Ethylenediamine (EDTA)									803400				
Dicalcium Phosphate	22.00	0.59	19.30	0.07	0.05	1.14	10	10		14400	300		100
Iron Sulfate						12.40				218400			
Magnesium Oxide	3.07	56.2									100		
Manganese Carbonate											478000		
Phosphate Deflourinated	32.00	0.42	18.00	0.08	4.90		10	20		6700	200		60
Phosphate Mono-Mono			22.50		16.68								
Potassium Iodide				21.00					681700				
Potassium Sulfate	0.15	0.61		41.84	0.09	17.35				710	10		
Salt					39.34								
Sodium Selenite					26.60							456000	
Sodium Sulfate					14.27	9.95							
Zinc Sulfate	0.02					17.68				10	10		363600

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