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

In this issue we will continue Dr. Diven's discussion on dietary energy focusing on how it relates to cow body weight gain or loss and how the rancher can manage it to minimize winter feeding costs.

Change in Net Energy (NE_{Δ})

When dietary net energy for maintenance (NEm) exceeds that needed by the cow for maintenance (M), gestation (G) and lactation (L) it goes for growth or body weight gain. Growth is the formation of new tissues, as occurs in young growing animals, or the replacement of tissue, as in mature animals. Mature cows that have lost weight and need to gain it back, e.g. for breeding, will need to consume more NEm than what they need for maintenance and lactation. The amount of additional NEm needed to gain weight is dependent upon her body condition. Cows in a low BCS (< 4) actually need less additional NEm to gain weight, initially anyway, compared to those in a higher BCS. The reason for this is due to the amount of energy needed to deposit adipose tissue cells (fat) compared to protein cells (muscle). A pound of fat contains 4.26 megacalories (Mcal) of energy whereas a pound of muscle contains 2.54 Mcal. However, because protein cells are associated with 3.5 to 4.5 times their weight in water they actually contain only 22 to 28% protein with the remaining 72 to 78% being water. Thus, the actual energy content of a pound of muscle is only about 0.64 Mcal (25% x 2.54). Because of this it does not take as much additional energy above that needed for maintenance and reproduction to add muscle tissue to a thin cow compared to the amount needed to add fat to a cow in good body condition. However, once muscle tissue has been replaced in the low BCS cow, fat deposition will occur requiring more additional energy. Note: Young, growing animals are depositing muscle and not fat so their body tissues contain more water, thus requiring less energy to gain weight.

Grazing and browsing animals in general gain weight during periods of high quality forage (late spring/early summer in Wyoming) and lose weight during periods of low quality forage (winter). The composition of this transient tissue is primarily fat, especially in high BCS (≥ 5) cows, with some protein. The fatter the cow the higher percentage of fat compared to protein (Figure 1).

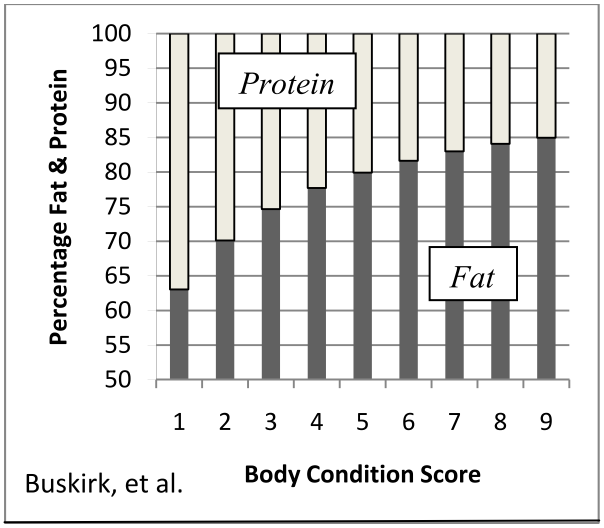

Figure 1: Relationship of percentage fat and protein in body weight change to body condition score (BCS).

From Figure 1 it can be seen that as an animal gains or losses weight (change in BCS) the relationship of fat to protein of the transient tissue increase or decreases. That is as an animal gets heavier a greater proportion of the gained tissue is fat compared to protein and likewise as an animal losses weight more fat is lost compared to protein. The importance of this is that it takes more and more calories for a cow to put on additional weight after she has met her maintenance and reproduction needs, especially the fatter she is, because the added weight being deposited is primarily fat. It also means that for a fat animal to lose weight a greater reduction in caloric intake has to occur, i.e. a high BCS cow can survive on its fat reserves longer than a thin cow.

The amount of NEm consumed above or below that needed for maintenance and reproduction by the cow is known as net energy for weight change and is represented by the symbol NE_Δ[1].

NE_Δ is the amount of Mcal gained or lost at a particular BCS when the cow changes weight (Table 1). For example, a cow in BCS 5 losses 3.02 Mcal of NE_Δ for every pound of weight she losses. Or for every 3.02 Mcal of NEm she is short of meeting her requirements she will lose a pound of weight. However, because NE_Δ is related to NEm for body weight gain by a factor of 2.95 this BCS 5.0 cow would need to consume 8.9 Mcal (3.02 * 2.95) of dietary NEm above her requirements to gain a pound of weight.

What this factor of 2.95 relates to is the Net Energy for gain (NEg) system used to calculate rations for growing animals. Instead of trying to use both NEm and NEg values of feeds and forages to determine how much body weight a cow could potential gain this factor is used instead to simplify the process (see example on page 3).

Table 1: Relationship between body condition score (BCS) and Mcal NE_Δ.

BCS	1.0	1.5	2.0	2.5	3.0	3.5
NE_Δ	1.70	1.86	2.03	2.19	2.36	2.52
BCS	4.0	4.5	5.0	5.5	6.0	6.5
NE_Δ	2.69	2.85	3.02	3.19	3.35	3.52
BCS	7.0	7.5	8.0	8.5	9.0	
NE_Δ	3.68	3.85	4.01	4.18	4.34	

$NE_\Delta = 1.3665 + 0.33073 * BCS$ (Adapted from Buskirk, et al.)

[1]Buskirk, D.D., R.P. Lemenager, and L.A. Horstman. 1992. Estimation of net energy requirements (NEm and NE_Δ) of lactating beef cows. J. Anim. Sci. 70:3867.

Example (Part II Appendix Tables 2 & 4):
An 1100 lb Empty Mature Body Weight (EMBW) cow in BCS 6.5 and in her 2nd month of lactation (medium milk) requires:

> *7.5 Mcal per day for NEm(M) and 6.6 Mcal per day for NEm(L) for a total daily requirement of 14.1 Mcal*

Forage supplies 13 Mcal NEm/day

Net energy amount for weight change is:
NEm (net) = 13 – 14.1 = -1.1 Mcal

The NE_{Δ} *for a cow in BCS 6.5 from Table 1:*
3.52 Mcal per pound loss in body weight

Daily weight loss (lb) = NEm (net) ÷ NE_{Δ}
-1.1 ÷ 3.52 = 0.31 lb weight loss/day

This cow will thus lose slightly over 2 lb/wk. Is this of concern? Considering that this cow would need to lose 44 pounds to drop a half a BCS probably not. It would take at least 4.5 months for her to lose this amount of weight and over this period her requirements will become less, although this assumes forage quality does not decrease significantly.

What if forage supplied 24 Mcal NEm/day?

Net energy amount for weight change is:
NEm (net) = 24 – 14.1 = 9.9 Mcal

The NE_{Δ} *for a cow in BCS 6.5 from Table 1:*
*3.52 Mcal * 2.95 = 10.4Mcal required for one pound gain in body weight*

Daily weight gain (lb) = NEm (net) ÷ NE_{Δ}
9.9 ÷ 10.4 = 0.95 lb weight gain/day

The cow would potentially gain about 7 lb/wk, taking it three months to add a BCS (88 lb), again assuming forage quality remained constant. However, the better condition she achieves the more Mcal NEm that will be required to gain a pound.

SOLUTIONS
Change in BCS
We'll now apply NE_{Δ} to evaluate a couple of energy management programs on a monthly basis. We'll use the same cow from the February newsletter (Part II of this series) for this evaluation, as well as the range forage data from the five Johnson County ranches.

1. Record EMBW of the cow: <u>1175</u> lb.

2. BCS desired for this cow at time of calving: <u>6.0</u>.

3. Record EBW of the cow (Appendix Table 2 in Part II): <u>998</u> lb.

4. Month in which she will calve: <u>March</u>.

5. From table 2 "NEm Balance (Mcal)" in Part II record the values from the "NEm Balance" column to same column in table 2 "Use of NE_{Δ} to Arrive at BCS" on page 6 below.

6. Enter the selected EBW weight and BCS in the columns "Weight (lb) Current" and "BCS" opposite the selected month (March).

7. Refer to table 1 "Relationship between BCS and NE_{Δ}" and locate the NE_{Δ} value that corresponds to the BCS selected. Enter this value (3.35) in the column headed "NE_{Δ}" opposite the month selected (March).

8. Calculate the weight change for April by dividing March's NEm Balance value by its NE_{Δ} value. *Note: If the NEm Balance value is positive divide it by the product of* NE_{Δ} ** 2.95.*
(-91 ÷ 3.35 = -27)

9. Enter this value (-27) in the column "Weight (lb) Change" for April.

10. Add this weight change value to March's current weight value.
    -27 + 998 = 971

11. Calculate a new BCS value by dividing the weight change value by 88, than add the quotient to the previous month's BCS value.
    -27/88 = -0.3 + 6.0 = 5.7

12. Calculate a new NE_{Δ} value by multiplying the new BCS value by 0.331 and adding to the product 1.37.
    5.7 * 0.331 = 1.89 + 1.37 = 3.26

We'll work down table 2 (page 6) one row at a time, repeating steps 7 through 11. Then move to the top of the table and continue down each row until we reach our selected month (March). We'll do the same for table 3 where May will be the calving month.

Discussion of the cow's total weight change and BCS for the production year for both calving months follows table 3 and relates to the following segment.

Unconventional View of Nutritionists and Ranchers

To optimize the cow-calf production system synchronization of the cow's nutrient needs with feed availability is required. As we know rangeland forage quality varies through the year with a period when it is low (late fall – early spring). There is nothing that can be done about seasonal range forage quality, so if the goal is to not have to supplement energy feeds the rancher needs to work with the cow's ability to store energy as body fat during the period of high quality forage for use when forage quality is poor.

A cow's energy requirement is highest for weight gain followed by that for maintenance plus lactation. As noted in Part II the cow must be in suitable body condition at time of calving and gaining weight in order to breed back to calve within a year's time. Dr. Diven suggests that the timing of the cow adding weight for breeding purposes should coincide with the highest quality of forage the land produces. For this region it is May into July. This also coincides with the longest photo-period when cattle tend to cycle sooner.

Figure 2 is a representation of this. Recall that in Part II of the series there was a similar chart except Mcal for NEm(M) was held constant. In the below chart NEm(M) also takes into account weight change that the cow will experience through a production year. With respect to the decline in Mcal NEm(M) it is not that the cow requires less but that she is not able to obtain all she needs from the forage. A rancher could provide an energy supplement during this period to ensure that the cow's NEm(M) requirement is met but is it cost effective or even needed! (See study on page 5). Granted if forage NEm is sufficiently low to cause a cow to go below a BCS 3.0 then it may well be warranted to provide an energy supplement to avoid this.

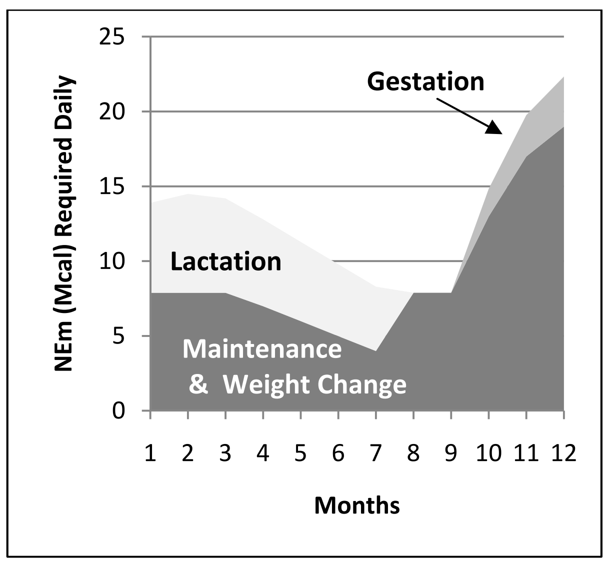

Figure 2: Accumulated NEm required for maintenance, gestation, lactation and weight change.

In a study at the USDA Meat Animal, Research Center near Clay Center, Nebraska[2] mature, non-pregnant, non-lactating cows were divided into two groups; a Control were each cow was fed 20 lb/day chopped pre-bloom smooth brome hay (0.59 Mcal NEm/lb & 16% Crude Protein) for the entire 224 day study, and a Treated were each cow was fed 13 lb/day of the same hay for the first 112 days (Phase 1) then 27 lb/day for the last 112 days (Phase 2). Total amount of hay fed each cow was the same for both groups (4480 lb). All cows were fed this hay for 120 days prior to the start of the study. Besides free access to water and a salt block containing sulfur no other feeds were provided prior to and during the study.

The Control cows gained an average of 30 pounds for the study period (Figure 3). Whereas the Treated cows lost an average of 90 pounds during Phase 1 but gained it back within the first two weeks of Phase 2 and gained an additional 70 pounds by the end of the study. Note the minimum weight loss during the last 28 days of Phase 1 by the Treated cows. This suggests that the cows were approaching equilibrium with regard to energy intake and use. The authors calculated that the Treated cows would have reached weight equilibrium by day 136 – if Phase 1 had lasted that long, meaning they would have maintained their weight thereafter.

Figure 4 shows retained energy by the cows further indicating that the Treated group was reaching weight equilibrium by the end of Phase 1 as retained energy for these cows was nearly 0 on day 112. When energy consumed equals energy lost the cow should be at maintenance. Although not shown, retained protein displayed similar curves as for energy.

[2]Freetly, H.C., and J.A. Nienaber. 1998. Efficiency of energy and nitrogen loss and gain in mature cows. J. Anim. Sci. 76:896.

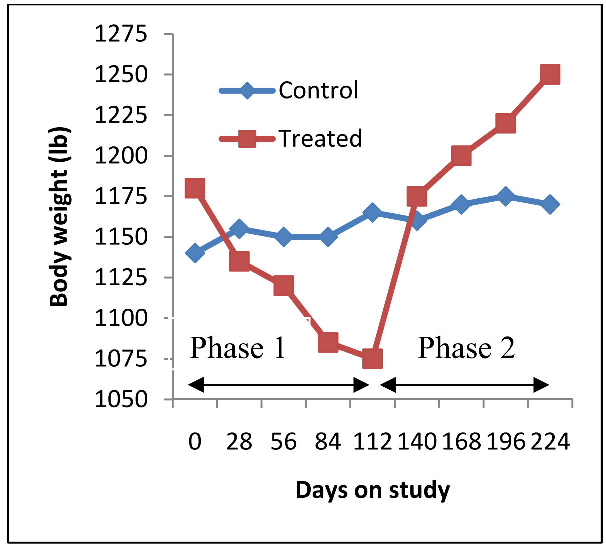

Figure 3: Cow body weight change of Control group (20 lb hay/day for entire 224 days); and Treated group (13 lb/day during Phase 1 and 27 lb/day during Phase 2).

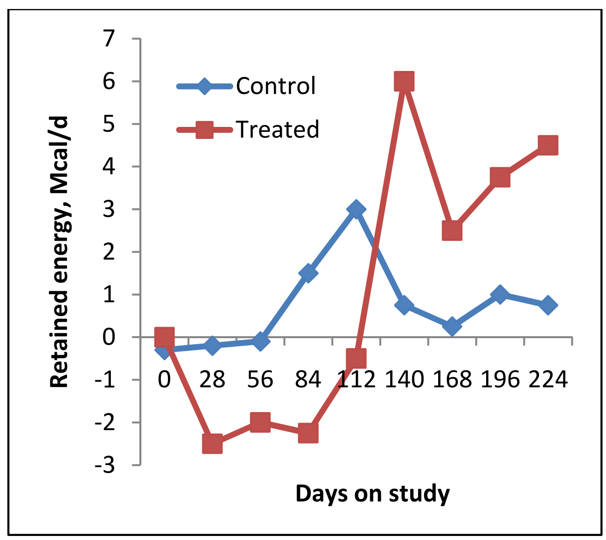

Figure 4: Retained energy by cows of Control group (20 lb hay/day for entire 224 days); and Treated group (13 lb/day during Phase 1 and 27 lb/day during Phase 2).

The bottom line is that a cow, especially if in good condition when she enters a period of low forage quality, can get by and actually do very well once forage quality improves.

SOLUTIONS EXAMPLE 1
March calving cow, calf weaned in October, EBW = 998 lb (EMBW = 1175 lb, at BCS 6)

Table 2: Use of NE_Δ to Arrive at BCS

Month	Days	NEm (Mcal) Balance	Weight (lb) Change	Weight (lb) Current	BCS	NE_Δ
January	31	50	10	1136	7.6	3.89
February	28	-4	4	1140	7.6	3.89
March	31	-91	-1	**998**	**6.0**	**3.35**
April	30	-46	-27	971	5.7	3.26
May	31	376	-14	957	5.5	3.19
June	30	228	40	997	6.0	3.35
July	31	251	23	1020	6.3	3.45
August	31	249	25	1045	6.6	3.55
September	30	242	24	1069	6.9	3.65
October	31	173	22	1091	7.1	3.72
November	30	215	16	1107	7.3	3.79
December	31	118	19	1126	7.5	3.85

Apr: Weight change = -91/3.35 = -27; Current weight = -27 + 998 = 971; BCS = -27/88 = -0.31 + 6.0 = 5.7; NE_Δ = 5.7 * 0.331 + 1.37 = 3.26.
May: Weight change = -46/3.26 = -14; Current weight = -14 + 971 = 957; BCS = -14/88 = -0.16 + 5.7 = 5.5; NE_Δ = 5.5 * 0.331 + 1.37 = 3.19.
Jun: Weight change = 376/ (3.19 * 2.95) = 40; Current weight = 40 + 957 = 997; BCS = 40/88 = 0.45 + 5.5 = 6.0; NE_Δ = 6.0 * 0.331 + 1.37 = 3.35.
Jul: Weight change = 228/ (3.35 * 2.95) = 23; Current weight = 23 + 997 = 1020; BCS = 23/88 = 0.26 + 6.0 = 6.3; NE_Δ = 6.3 * 0.331 + 1.37 = 3.45.
Aug: Weight change = 251/ (3.45 * 2.95) = 25; Current weight = 25 + 1020 = 1045; BCS = 25/88 = 0.28 + 6.3 = 6.6; NE_Δ = 6.6 * 0.331 + 1.37 = 3.55.
Sep: Weight change = 249/ (3.55 * 2.95) = 24; Current weight = 24 + 1045 = 1069; BCS = 24/88 = 0.27 + 6.6 = 6.9; NE_Δ = 6.9 * 0.331 + 1.37 = 3.65.
Oct: Weight change = 242/ (3.65 * 2.95) = 22; Current weight = 22 + 1069 = 1091; BCS = 22/88 = 0.25 + 6.9 = 7.1; NE_Δ = 7.1 * 0.331 + 1.37 = 3.72.
Nov: Weight change = 173/ (3.72 * 2.95) = 16; Current weight = 16 + 1091 = 1107; BCS = 16/88 = 0.18 + 7.1 = 7.3; NE_Δ = 7.3 * 0.331 + 1.37 = 3.79.
Dec: Weight change = 215/ (3.79 * 2.95) = 19; Current weight = 19 + 1107 = 1126; BCS = 19/88 = 0.22 + 7.3 = 7.5; NE_Δ = 7.5 * 0.331 + 1.37 = 3.85.
Jan: Weight change = 118/ (3.85 * 2.95) = 10; Current weight = 10 + 1126 = 1136; BCS = 10/88 = 0.11 + 7.5 = 7.6; NE_Δ = 7.6 * 0.331 + 1.37 = 3.89.
Feb: Weight change = 50/ (3.89 * 2.95) = 4; Current weight = 4 + 1136 = 1140; BCS = 4/88 = 0.05 + 7.6 = 7.6; NE_Δ = 7.6 * 0.331 + 1.37 = 3.89.
Mar: Weight change = -4/3.89 = -1; Current weight = -1 + 1140 = 1139; BCS = -1/88 = -0.01 + 7.6 = 7.6; NE_Δ = 7.6 * 0.331 + 1.37 = 3.89.

The cow finished the production year at a heavier weight (+141 lb) and higher BCS (+1.6) then what she started at. This would be desirable since the effects of weather were not considered.

SOLUTIONS EXAMPLE 1
May calving cow, calf weaned in December, EBW = 998 lb (EMBW = 1175 lb, at BCS 6)

Table 3: Use of NE_{Δ} to Arrive at BCS

Month	Days	NEm (Mcal) Balance	Weight (lb) Change	Weight (lb) Current	BCS	NE_{Δ}
January	31	158	6	1144	7.7	3.90
February	28	49	14	1158	7.8	3.95
March	31	-13	4	1162	7.9	3.96
April	30	26	-4	1158	7.8	3.95
May	31	385	8	**998**	**6.0**	**3.35**
June	30	204	39	1037	6.4	3.50
July	31	220	20	1057	6.7	3.57
August	31	218	21	1078	6.9	3.65
September	30	208	20	1098	7.1	3.73
October	31	142	19	1117	7.3	3.80
November	30	86	13	1130	7.5	3.84
December	31	72	8	1138	7.6	3.87

The same procedure as done for table 2 is employed. The monthly "NEm Balance" values are different compared to table 2's due to shifting calving from March to May (See Solutions segment in Part II). However, the Mcal of "NEm Balance" totaled for the year are the same for both scenarios. With May calving, the cow finished the production year 168 lb heavier and in a BCS 1.8 greater then what she started the year at. The reason for her finishing even heavier and in a higher BCS compared to when calving in March was that her NEm requirements were met by the available range forage in all months, except March. Whereas with March calving her NEm requirements were not met in February, March, and April.

The take home message from these two calving scenarios is that range forage in Johnson County, Wyoming, and most likely the Northern Great Plains as a whole, contains an adequate amount of NEm to meet the needs of a beef cow regardless of when she calves. Granted, if she calves in late winter/ early spring there is a greater chance the forage will not meet her NEm needs but if she was able to gain weight when forage quality was good she can lose some weight when conditions are not favorable and still probably be in an adequate BCS at time of calving. Supplementation of energy feeds generally should not be needed, especially if there is an adequate amount of grazable range forage. However, protein is another matter and will be discussed in the next issue.

A comment about the Freetly and Nienaber study reported above. Had the cows been in their last trimester of pregnancy, or lactating, the Treated group most likely would have lost even more weight and not gained nearly as much when the hay amount was doubled. However, the Control group would also have lost weight but they probably would have reached equilibrium at some point.

This study shows that cows can lose body condition, due either to low quality or low quantity feed, but once an adequate amount of good quality feed is available, e.g. green, growing grass, they will gain the weight back, i.e. there is no need to try and maintain their weight through the year. Providing an energy feed is not generally warranted but protein is.

The following Appendix tables and formulas are from Chapter 6 – BCS REVISTED: Non-Empirical Scoring. It is provided primarily for your information in hopes of helping you to better understand the material presented so far and help you determine the weight of your cow herd – mature cows, replacement heifers, and bulls – for management purposes.

Appendix Table 1: Body condition score (BCS) in relation to body fat (Fox, et al. 1988[3]).

BCS	1	2	3	4	5	6	7	8	9
% Fat	5.0	9.4	13.7	18.1	22.5	26.9	31.2	35.6	40.0

% Fat = BCS * 4.3733 + 0.6222

Appendix Table 2: Height and weight of cows relative to frame score (Fox, et al. 1988[3]).

Frame Score	1	2	3	4	5	6	7	8	9
Height (in)	44.6	46.5	48.2	50.0	52.0	53.9	55.8	57.5	59.4
Weight (lb)[1]	901	972	1035	1102	1177	1248	1319	1382	1453

[1]Weight = Empty Mature Body Weight (EMBW)
*EMBW = Height (in) * 37.35 – 765. Example: 50.0 * 37.35 – 765 = 1867.5 – 765 = 1102*

Fox and Black (1984)[4] calculated EMBW as that weight above which the energy content of gain was > 8 kcal/g. Body weight gain requiring this amount of energy is comprised solely of fat, i.e., all additional weight gain above a cow's EMBW is fat. A lower energy requirement (≤ 8 kcal/g) would indicate deposition of other tissues such as protein in muscle.

When EBW = EMBW, the body fat content for all frame sizes is 35.0% (Owens, et al. 1993[5]). According to Appendix Table 1, when cattle achieve EMBW their BCS is ≈ 7.85.

BCS 8 = 35.6% fat and BCS 7 = 31.2% fat, the difference is 4.4%.
35.6% – 35.0% = 0.6%; 0.6% ÷ 4.4% = 0.136. BCS 8.0 – 0.136 = 7.864 (≈ 7.85)

Appendix Table 3 (page 9) indicates the EBW relative to BCS for cows of various sized frames. It is obvious that the low-scoring cows are near death. The estimates were made by allowing 8.2% (0.082) of EMBW for each change of one in BCS. Again, when EBW is equal to EMBW, BCS is 7.85. *EBW = ((BCS – 7.85) * 0.082 * EMBW) + EMBW (for BCS ≤ 7.85)*
*Example: EBW of a cow in a BCS of 5.0 = ((5.0 – 7.85) * 0.082 * 1102 lb) + 1102 lb*
*EBW = (-2.85 * 0.082 * 1102) + 1102 = -0.2337 * 1102 + 1102 = -258 + 1102 = 845 lb*

[3]Fox, D.G., C.J. Sniffen, and J.D. O'Connor. 1988. Adjusting nutrient requirements of beef cattle for animal and environmental variations. J. Anim. Sci. 66:1475.

[4]Fox, D.G. and J.R. Black. 1984. A system for predicting body composition and performance of growing cattle. J. Anim. Sci. 58:725.

[5]Owens, F.N., P. Dubeski, and C.F. Hanson. 1993. Factors that alter the growth and development of ruminants. J. Anim. Sci. 71:3138.

Appendix Table 3: Body weight relative to body condition score (BCS).

Frame Score	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Height (in)	**44.6**	**46.5**	**48.2**	**50.0**	**52.0**	**53.9**	**55.8**	**57.5**	**59.4**
EMBW (lb)	**901**	**972**	**1035**	**1102**	**1177**	**1248**	**1319**	**1382**	**1453**
BCS	**Empty Live Body Weight (EBW) in pounds[1]**								
1.0	395	426	454	483	516	547	578	606	637
1.5	432	466	496	528	564	598	632	663	697
2.0	469	505	539	574	612	649	686	719	756
2.5	505	545	581	619	661	700	740	776	816
3.0	542	585	623	664	709	752	794	833	875
3.5	579	625	666	709	757	803	848	889	935
4.0	616	665	708	754	805	854	903	946	995
4.5	653	705	751	799	854	905	957	1003	1054
5.0	690	744	793	845	902	956	1011	1059	1114
5.5	727	784	836	890	950	1007	1065	1116	1173
6.0	764	824	878	935	998	1059	1119	1173	1233
6.5	801	864	920	980	1047	1110	1173	1229	1292
7.0	838	904	963	1025	1095	1161	1227	1286	1352
7.5	875	944	1005	1071	1143	1212	1281	1343	1412
8.0	912	983	1048	1116	1191	1263	1335	1399	1471
8.5	949	1023	1090	1161	1240	1314	1389	1456	1531
9.0	986	1063	1133	1206	1288	1366	1443	1513	1590

[1]Empty Live Body Weight (EBW) = ((BCS – 7.85) * 0.082 * (EMBW) ± EMBW (Note: for BCS ≤ 7.85 add EMBW for BCS > 7.85 subtract EMBW)

EBW (empty (live) body weight) is the body weight of the animal minus gastrointestinal contents; it is 0.851 * SBW (shrunk body weight)[6]. Thus, if a cow weighs 1200 lb after standing overnight without feed and water (4% shrink) her EBW would be 1021 lb (0.851 * 1200 lb).

Appendix Table 4: Mature cow hip height (in) and frame score.

Age (Months)	**Frame Score**								
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
24	43.1	45.0	46.9	48.8	50.7	52.5	54.5	56.4	58.2
30	43.8	45.8	47.5	49.4	51.3	53.1	55.1	57.0	58.9
36	44.2	46.1	48.0	49.8	51.8	53.6	55.5	57.2	59.2
48	44.6	46.5	48.2	50.0	52.0	53.9	55.8	57.5	59.4

Following equations can be used to determine frame scores of taller cows then listed:
*24 months = -21.824 + 0.5293 * height; ex: -21.824 + 0.5293 * 48.8 = -21.824 + 25.8294 = 4*
*30 months = -22.308 + 0.5321 * height; ex: -22.308 + 0.5321 * 49.4 = -22.308 + 26.28574 = 4*
*36 months = -22.781+ 0.5373 * height; ex: -22.781 + 0.5373 * 49.8 = -22.781 + 26.7575 = 4*
*48 months = -23.134 + 0.5413 * height; ex: -23.134 + 0.5413 * 50.0 = -23.134 + 27.065 = 4*

[6]National Academy of Sciences, 1996 (Update 2000). Nutrient Requirements of Beef Cattle, Seventh revised edition. National Academy Press, 2101 Constitution Avenue, NW, Washington, DC 20418.

The Beef Improvement Federation[6] has developed equations for estimating frame score of heifers and bulls from five to 21 months of age. The validity of the equations will depend to a considerable extent upon nutritional level. The individual animal should maintain the same frame score throughout life. Tabled values and equations for heifers and bulls follows:

Appendix Table 5: Heifer hip height (in) and frame score for ages five to 21 months.

Age (Months)	**Frame Score**								
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
5	33.1	35.1	37.2	39.3	41.3	43.4	45.5	47.5	49.6
6	34.1	36.2	38.2	40.3	42.3	44.4	46.5	48.5	50.6
7	35.1	37.1	39.2	41.2	43.3	45.3	47.4	49.4	51.5
8	36.0	38.0	40.1	42.1	44.1	46.2	48.2	50.2	52.3
9	36.8	38.9	40.9	42.9	44.9	47.0	49.0	51.0	53.0
10	37.6	39.6	41.6	43.7	45.7	47.7	49.7	51.7	53.8
11	38.3	40.3	42.3	44.3	46.4	48.4	50.4	52.4	54.4
12	39.0	41.0	43.0	45.0	47.0	49.0	51.0	53.0	55.0
13	39.6	41.6	43.6	45.5	47.5	49.5	51.5	53.5	55.5
14	40.1	42.1	44.1	46.1	48.0	50.0	52.0	54.0	56.0
15	40.6	42.6	44.5	46.5	48.5	50.5	52.4	54.4	56.4
16	41.0	43.0	44.9	46.9	48.9	50.8	52.8	54.8	56.7
17	41.4	43.3	45.3	47.2	49.2	51.1	53.1	55.1	57.0
18	41.7	43.6	45.6	47.5	49.5	51.4	53.4	55.3	57.3
19	41.9	43.9	45.8	47.7	49.7	51.6	53.6	55.5	57.4
20	42.1	44.1	46.0	47.9	49.8	51.8	53.7	55.6	57.6
21	42.3	44.2	46.1	48.0	50.0	51.9	53.8	55.7	57.7

*Frame Score = -11.7086 + 0.4723 * (height) – 0.0239 * (Days of age) + 0.0000146 * (Days of age)^2 + 0.0000759 * (height) * (Days of age)*

*Example: 10 month old heifer, hip height = 43.7 inches; 10 months = 304 days (365/12 * 10)*
*-11.7086 + 0.4723 * (43.7) – 0.0239 * (304) + 0.0000146 * (304)^2 + 0.0000759 * (43.7) * (304)*
-11.7086 + 20.64 – 7.27 + 1.35 + 1.01 = 4

Appendix Table 6: Mature bull hip height (in) and frame score.

Age (Months)	**Frame Score**								
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
24	46.4	48.3	50.3	52.3	53.9	56.0	58.0	60.0	62.0
30	47.3	49.3	51.3	53.2	54.9	57.0	59.0	61.0	63.0
36	48.0	50.0	51.9	53.8	55.5	57.5	59.5	61.5	63.5
48	48.5	50.4	52.3	54.1	55.9	58.0	60.0	62.0	63.9

Following equations can be used to determine frame scores of taller bulls then listed:
*24 months = -22.646 + 0.5105 * height; ex: -22.646 + 0.5105 * 52.3 = -22.646 + 26.699 = 4*
*30 months = -23.054 + 0.5089 * height; ex: -23.054 + 0.5089 * 53.2 = -23.054 + 27.073 = 4*
*36 months = -23.734+ 0.5158 * height; ex: -23.734 + 0.5158 * 53.8 = -23.734 + 27.750 = 4*
*48 months = -24.073 + 0.5180 * height; ex: -24.073 + 0.5180 * 54.1 = -24.073 + 28.024 = 4*

Appendix Table 7: Bull hip height (in) and frame score for ages five to 21 months.

Age	Frame Score								
(Months)	1	2	3	4	5	6	7	8	9
5	33.5	35.5	37.5	39.5	41.6	45.6	45.6	47.7	49.7
6	34.8	36.8	38.8	40.8	42.9	44.9	46.9	48.9	51.0
7	36.0	38.0	40.0	42.1	44.1	46.1	48.1	50.1	52.2
8	37.2	39.2	41.2	43.2	45.2	47.2	49.3	51.3	53.3
9	38.2	40.2	42.3	44.3	46.3	48.3	50.3	52.3	54.3
10	39.2	41.2	43.3	45.3	47.3	49.3	51.3	53.3	55.3
11	40.2	42.2	44.2	46.2	48.2	50.2	52.2	54.2	56.2
12	41.0	43.0	45.0	47.0	49.0	51.0	53.0	55.0	57.0
13	41.8	43.8	45.8	47.8	49.8	51.8	53.8	55.8	57.7
14	42.5	44.5	46.5	48.5	50.4	52.4	54.4	56.4	58.4
15	43.1	45.1	47.1	49.1	51.1	53.0	55.0	57.0	59.0
16	43.6	45.6	47.6	49.6	51.6	53.6	55.6	57.5	59.5
17	44.1	46.1	48.1	50.1	52.0	54.0	56.0	58.0	60.0
18	44.5	46.5	48.5	50.5	52.4	54.4	56.4	58.4	60.3
19	44.9	46.8	48.8	50.8	52.7	54.7	56.7	58.7	60.6
20	45.1	47.1	49.1	51.0	53.0	55.0	56.9	58.9	60.9
21	45.3	47.3	49.2	51.2	53.2	55.1	57.1	59.1	61.0

*Frame Score = -11.548 + 0.4878 * (height) – 0.0289 * (Days of age) + 0.00001945 * (Days of age)^2 + 0.0000334 * (height) * (Days of age)*

*Example: 10 month old bull, hip height = 45.3 inches; 10 months = 304 days (365/12 * 10)*
*-11.548 + 0.4878 * (45.3) – 0.0289 * (304) + 0.00001945 * (304)^2 + 0.0000334 * (45.3) * (304)*
-11.548 + 22.1 – 8.8 + 1.8 + 0.46 = 4

[6] Beef Improvement Federation: Guidelines for uniform beef improvement programs, Eighth Edition. 2002. Can be obtained at www.beefimprovement.org. Select Library and then Guideline Information