Defining Value and Requirements in Cow Rations: What is a Calorie Worth?

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Introduction

In the United States and globally, extensive beef cattle production systems are challenged by increasing competition for land, access to capital, and a resulting increase in total costs of production. Particularly in the United States, these pressures may be increasing the sensitivity to risk in cow-calf enterprises. When these pressures are exacerbated by weather perturbations, overall production has declined and has shown reduced response to economic signals to expand. This reduction in primary production impacts productivity and performance of the entire beef supply chain.

Global population dynamics, including both population increases and increasing affluence of consumers in developing nations, indicate a likely increase in protein and beef demand. The confluence of a declining production base and increasing global demand suggest a need for innovation in production management to improve the overall sustainability of beef production systems and to enhance the competitiveness of beef producers.

Through the generosity of the Kenneth S. and Caroline McDonald Eng Foundation, we have initiated a program of work to foster innovation in beef production systems. The primary goal of this program is to enhance the overall competitiveness of US beef production systems. Key strategies to achieve this goal are:

1) Improve the economic and environmental sustainability by increasing the efficiency of primary production systems

2) Increase land-use efficiency of extensive systems

3) Develop and describe decision support systems to optimize management change

System Framework

As managers contemplate methods to increase the performance of cow-calf enterprises, a key consideration is development of a "model" of the system that will allow effective decision making. The ranch system, from the perspective of cow calf production, can be viewed as a transaction in calories. The ranch produces calories each production cycle that are consumed by livestock and converted into salable product. It is our objective to utilize this mental model to develop a method by which producers can effectively describe the "value" of a calorie, evaluate the cost of calories from the ranch and from exogenous sources, and utilize this comparison to make decisions regarding expansion and/or intensification of the cow-calf enterprise. Additionally, the development of this mental model of cow-calf production allows identification of knowledge gaps that should be filled in order to refine projections and identify future opportunities to enhance production efficiency.

As an initialization process, the production of consumable calories is estimated as being in balance with the demand from a properly stocked cow-calf operation. Under this scenario, the ranch produces 100% of the caloric requirement for production; deficiencies in protein and/or minerals are met with supplementation strategies. Thus, estimating the energy requirements yearlong for the cow herd is a proxy for consumable calorie production. Note that in most ranching systems, the production of calories (plant growth) and their consumption (grazing, feeding of harvested forages grown on-site) do not necessarily occur simultaneously. Calories may be produced in excess of demand in one period, and consumed in excess of production in another, to achieve effective use yearlong. This premise is foundational to most rangeland or grazing management strategies (i.e., stockpiling forage).

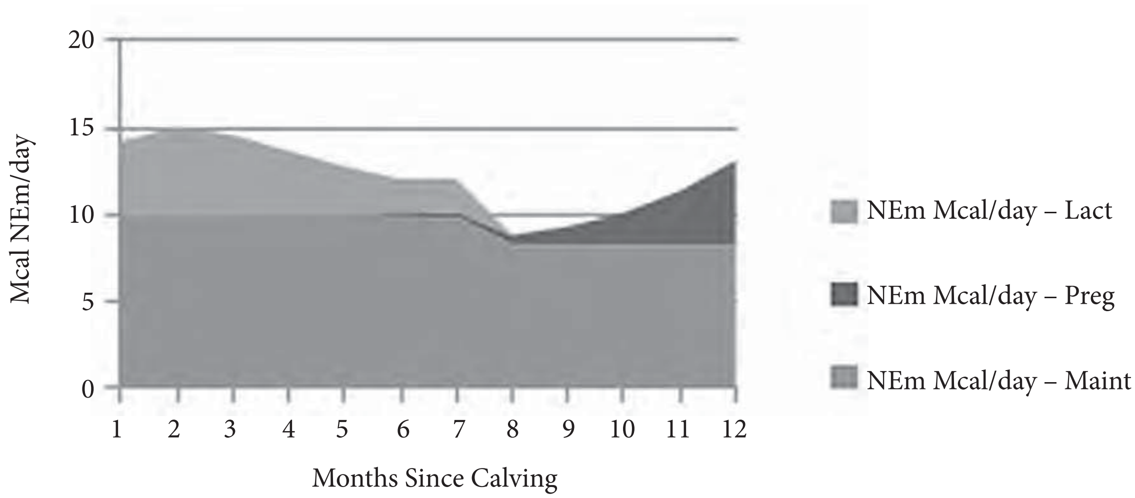

Figure 1: Energy requirements of a 1,200 lb. Brangus cow throughout a production cycle.

Figure 1 shows the energy requirements for maintenance, lactation, and pregnancy during a production year (beginning at calving) for a 1,200 lb. Brangus cow derived from NRC models (2000). The marked reduction in lactation, maintenance and total requirements at the end of month 7 results from weaning at 205 d post calving. The escalation in energy requirements from month 8 through 12 is a result of fetal growth. At calving the subsequent year, requirements escalate again due to lactation. Consistent with the framework we describe, we will consider these requirements as the base demand for calories in the system. When totaled for the production year, the cow has a calorie demand of 4,474 Mcal NEm.

The values above do not include any additional energy requirement for activity in a grazing system. Estimates of this energy demand for activity vary widely among standard models, and comparative experiments to establish this value are limited and may be an important area of future research. Currently, the NRC (2000) uses an equation to estimate energy requirements for grazing activity based on forage intake, forage energy density, severity of terrain, forage availability per unit area, and cow size. Using typical values in this equation yields estimated energy demand due to grazing activity of 2.0 to 2.4 Mcal/d, or 730 to 876 Mcal/cow annually. This represents an additional 15% to 24% increase in total daily energy demand, dependent on month of determination. For purposes of this article, we will assume an increase of 2.2 Mcal/d yearlong, resulting in a total caloric demand for the baseline system of 5,277 Mcal/cow annually. For a 'balanced' system, this represents the caloric production capacity of the ranch on an annual, per cow basis.

Establishing the Value of a Calorie

Using this base framework of a balanced system, the value of a calorie can be estimated as the revenue generating potential of the energy unit net of costs of production. *Table 1* depicts a budget for a cow calf operation in West Central Texas (Thompson, 2013); this is representative of a 500-cow rangeland based operation with no reliance on exogenous calories to meet energy demands. In this budget, weaning rate is based at 85%, cow culling rate at 15%, replacement females retained to offset culling loss (resulting in a loss of revenue), and bulls culled at 25% of the battery each year. Land costs are shown per cow unit per year, as if the land were rented.

For this base case, the value of produced calories is equal to the per cow revenue ($667.02) divided by the energy demand per cow (5,277 Mcal, from above), or 12.64 cents per Mcal NEm. One approach to estimating the cost of these calories is equal to the total cost divided by total calories supplied, or $569.41 / 5,277 = 10.79 cents per Mcal. Alternatively, the fixed cost base per calorie might be considered the true cost of "acquiring" the calories, and the variable cost portion of the total calorie cost might be considered the cost of "harvesting" them. From this perspective, the costs of acquiring any additional calories would be equivalent to the purchase of land and improvements and fixed costs associated with them. Assuming that variable costs remained constant, the maximum value of land purchased (i.e., breakeven value of purchased calories) would be approximately $3,350 per AU (5% interest, 30 year note, 100% debt). In the region of Texas reflected in this budget, purchase costs are approximately 10 times this amount.

Table 1. Cow-calf enterprise budget for West Central Texas, Extension District 7 (adapted from Thompson, 2013).

Revenue	*Head*	*Qty.*	*$/Unit*	*$/Cow*	*Enterprise Total*
Steer	0.43	5.25	$ 156.00	$ 352.17	$ 176,085.00
Heifer	0.27	4.75	$ 148.00	$ 189.81	$ 94,905.00
Cull Cow	0.15	10	$ 74.00	$ 111.00	$ 55,500.00
Cull Bull	0.01	18	$ 78.00	$ 14.04	$ 7,020.00
Total Revenue				***$ 667.02***	***$ 333,510.00***
Variable Costs					
Supplies		1	$ 18.35	$ 18.35	$ 9,175.00
Marketing Expenses		1	$ 23.35	$ 23.35	$ 11,672.85
Supplements		1	$ 78.00	$ 78.00	$ 39,000.00
Vet. Supplies		1	$ 16.50	$ 16.50	$ 8,250.00
Fuel		1	$ 67.00	$ 67.00	$ 33,500.00
Repairs		1	$ 47.50	$ 47.50	$ 23,750.00
Labor		1	$ 63.00	$ 63.00	$ 31,500.00
Utilities		1	$ 24.00	$ 24.00	$ 12,000.00
Interest		1	$ 12.66	$ 12.66	$ 6,331.79
Livestock Depr.		1	$ 13.20	$ 13.20	$ 6,600.00
Total Variable Costs				***$ 363.56***	***$ 181,779.64***
Fixed Costs					
Brush Control		1	$ 6.67	$ 6.67	$ 3,335.00
Equipment Depr.		1	$ 52.18	$ 52.18	$ 26,090.00
Property Insurance		1	$ 27.00	$ 27.00	$ 13,500.00
Land Costs (rent)		1	$ 120.00	$ 120.00	$ 60,000.00
Total Fixed Costs				**$ 205.85**	**$ 102,925.00**
Total Costs				**$ 569.41**	**$ 284,704.64**
Returns				**$ 97.61**	**$ 48,805.36**

The value of additional calories can be estimated based on the expected change in revenue relative to the change in calorie supply. Because one AU is expected to yield $667.02 in revenues, and the energy change has been established, the gross value of purchased calories does not change unless revenue is increased for the additional units, or if caloric demand is reduced (efficiencies are gained). Thus, the scarcity of additional lease land (at or below $217 per AU) due to competing demands, and the apparent disparity in production value and purchase price for additional owned land make expansion difficult or impossible even if current margins are positive. Therefore, expansion of the primary production base is constrained and the system is very brittle in the face of market or weather shocks.

Changing the System

An alternative to expanding the calorie base through land purchase or rental is intensification and purchase of exogenous calories (produced off-site and imported). The costs of acquiring exogenous calories include the purchase of ingredients and additional depreciation expense of required equipment or improvements; the costs of "harvesting" them would costs of mixing and delivering feed. If these added calories are delivered to additional cows above the base herd size, then the total costs of additional calories must also include the non-feed variable costs reflected in the base per additional cow. Using the framework of the system as calorie driven allows for this decision to be addressed.

Table 2. **Energy demand (Mcal NEm/cow) by month for 1200 lb. Brangus cows in a reallocated system.**

Item	*Mar*	*Apr*	*May*	*Jun*	*Jul*	*Aug*	*Sep*	*Oct*	*Nov*	*Dec*	*Jan*	*Feb*	*Total*
Days	31	30	31	30	31	31	30	31	30	31	31	28	365
Base energy demand	509	519	520	476	464	442	427	342	346	382	421	429	5277
Reallocated forage energy	727	740	742	679	662	630	609	488	—	—	—	—	5277
Required exogenous energy	—	—	—	—	—	—	—	—	493	545	600	612	2250

Table 2 shows the caloric demand per cow in the base scenario, and an alternate scenario in which cows graze from calving to weaning and are placed into an intensive system for 120 d between weaning and calving. Note that the increase in total energy demand (sum of reallocated forage energy and required exogenous energy) reflects increased capacity (head count) of the new system — energy requirements of individuals have not changed.

In this model, it is assumed that produced calories are transferrable within the production year. Therefore, placing cows into confinement releases a portion of the calories produced; these calories can be utilized by additional cows during the lactation period. All calories required during the dry period are imported from outside sources. The confinement period includes Nov through Feb, releasing 1,578 calories from forage. This represents an increase in harvestable forage from Mar through Oct, an increase of 42.6% of the base supply during those months. Adding cows to harvest this released supply results in an equivalent increase in demand, bringing the forage system back into balance. The new total number of cows (i.e., 1.426 in this example) results in a re-estimated demand during the 120-d confinement period of 2,250 Mcal that must be purchased. The new system total demand is 7,527 calories to support the 42.6% increase in cow numbers (see *Table 2*).

A portion of the energy demand in the base scenario is associated with grazing activity. If this requirement is reduced or eliminated during confinement feeding periods, then the apparent increase in total caloric demand is not a direct increase as depicted above. Rather, the reduction in demand will result in an increase in system efficiency (outputs are held constant while inputs per productive unit are reduced). However, as noted previously, the lack of direct data make this assumption difficult to validate. In *Table 3*, recalculated to a per cow basis (rather than 1.426 cows), models reflecting no change in activity requirement, a 50% reduction in activity requirement, or a 100% reduction in activity requirements are shown. These changes result in 8.4% and 16.7% reductions in confinement period energy demand, respectively.

Assuming that the activity requirement is truly eliminated by placing cows into confinement, the increase in cattle numbers and resulting increase in output is greater than the increase in added inputs, increasing system efficiency. Base system efficiency (lbs. of calf sold per Mcal energy consumed) increases by approximately 5.2% on an energy utilization basis. Perhaps more importantly, production efficiency per unit of land (the constraining resource) is increased by over 42%, as total output increased without a corresponding increase in the land area of the ranch.

Table 3. Energy (Mcal NEm/cow) required for 1200 lb. Brangus cows in a 120-d confinement feeding period supported by exogenous energy purchases, and modified by reductions in energy required for grazing activity.

Scenario	*Forage Energy*	*Exogenous Energy*	*Total Energy*	*Exogenous Change*	*System Change*
No activity req. change	3699	1578	5277	0.0%	0.0%
Reduce activity req. 50%	3699	1446	5146	-8.4%	-2.5%
Reduce activity req. 100%	3699	1314	5013	-16.7%	-5.0%

Table 4. Comparison of enterprise budgets for 500-cow extensive system and 713-cow strategically intensified system.

Revenue	*$/Cow*	*Enterprise Total (500 cows)*	*$/Cow*	*Enterprise Total (713 cows)*
Steer	$ 352.17	$ 176,085.00	$ 352.17	$ 251,179.43
Heifer	$ 189.81	$ 94,905.00	$ 189.81	$ 135,378.84
Cull Cow	$ 111.00	$ 55,500.00	$ 111.00	$ 79,168.91
Cull Bull	$ 14.04	$ 7,020.00	$ 14.04	$ 10,013.80
Total Revenue	***$ 667.02***	***$ 333,510.00***	***$667.02***	***$ 475,740.99***
Variable Costs				
Supplies	$ 18.35	$ 9,175.00	$ 18.35	$ 13,087.83
Marketing	$ 23.35	$ 11,672.85	$ 23.35	$ 16,650.93
Supplements	$ 78.00	$ 39,000.00	$ 54.68	$ 39,000.00
Vet. Supplies	$ 16.50	$ 8,250.00	$ 16.50	$ 11,768.35
Fuel	$ 67.00	$ 33,500.00	$ 67.00	$ 47,786.64
Repairs	$ 47.50	$ 23,750.00	$ 47.50	$ 33,878.59
Labor	$ 63.00	$ 31,500.00	$ 54.26	$ 38,700.00
Utilities	$ 24.00	$ 12,000.00	$ 24.00	$ 17,117.60
Interest	$ 12.66	$ 6,331.79	$ 12.66	$ 9,032.10
Livestock Depreciation	$ 13.20	$ 6,600.00	$ 13.20	$ 9,414.68
Purchased Energy	—	—	$ 142.16	$ 101,393.27
Total Variable Costs	***$ 363.56***	***$ 181,779.64***	***$473.66***	***$ 337,830.00***
Fixed Costs				
Brush Control	$ 6.67	$ 3,335.00	$ 4.68	$ 3,335.00
Equipment Depreciation	$ 52.18	$ 26,090.00	$ 44.27	$ 31,574.00
Property Insurance	$ 27.00	$ 13,500.00	$ 18.93	$ 13,500.00
Land Costs (rent)	$ 120.00	$ 60,000.00	$ 84.12	$ 60,000.00
Total Fixed Costs	**$ 205.85**	**$ 102,925.00**	**$ 152.00**	**$ 108,409.00**
Total Costs	**$ 569.41**	**$ 284,704.64**	**$ 625.66**	**$ 446,239.00**
Returns	**$ 97.61**	**$ 48,805.36**	**$ 41.36**	**$ 29,501.98**

The Value of Change

The strategic intensification of the modeled system results in apparent efficiency gains. The value of the energy required to drive this change can be estimated as the increase in total revenues derived from the change divided by the increase in energy required for the new system. Revenues per cow do not change in this framework, as we have assumed no changes in per cow productivity. Total revenue increases are therefore directly related to the increase in total capacity of the system. *Table 4* compares the original enterprise budget with 500 cows to the new enterprise budget with 713 cows.

Drawing from the data in *Tables 3* and *4*, the value of total calories in both the base case and the new case can be compared. Perhaps more importantly, the value (and thus breakeven cost) of the required exogenous energy can be computed. In the original case, the gross value of energy was 12.64 cents per Mcal ($667.02 / 5277 Mcal). Because of reductions in the per cow energy demand due to transition to the partial confinement system, the total value of energy in the new system is greater ($667.02/5013 Mcal, or 13.31 cents per Mcal). The value of the exogenous energy is equal to the change in total revenues ($142,231) per change in total energy required in the system (936,939 Mcal) or 15.18 cents per Mcal. For context, this is the breakeven equivalent for purchasing and delivering the exogenous energy.

While transitioning to the intensive system increased the apparent value of energy, this transition also created additional costs. While variable costs were forecast to stay relatively constant on a unit basis, unit variable cost estimates were reduced for supplements (fewer days on pasture to receive) and for labor expense. However, these reductions were not sufficient in this budget to offset key driver of cost in this setting, the purchase cost of additional energy to support the confinement period. Increases in total costs for fuel, labor, and other variable costs was deemed sufficient to handle the additional resource expenditure required to support this system, but definitive data are lacking.

Fixed costs were expected to decline on a unit basis, as there are more animals to dilute total costs. Fixed costs include purchase and immediate placement of a tractor, feeding equipment and feed bunks to support development of an intensive system. Notable, all fixed costs declined. Despite the reduction in unit costs, they were not sufficient to overcome the increased costs of feeding.

Clearly, these values are estimates and should not be taken as an exhaustive report of the system. The key object is to develop a framework from which strategies can be developed, evaluated, and acted upon.

Key Takeaways

Establishing the framework for a continuing effort to improve the efficiency of primary production systems is essential for identification of critical knowledge gaps. With this framework, the value of intensification can be clearly demonstrated; however, the cost of implementation may be high. The reality that in many regions of the United States, increasing competition for land is a constraint on expansion of production systems is also evident, and land use efficiency appears to be improved with intensification. Opportunities to improve system energetic efficiency may exist, but insufficient data regarding plasticity of cow requirements in confinement systems exist to make definitive forecasts. Additional research is also needed to develop tools to optimize formulation, manufacturing and delivery systems for feedstuffs in these systems to capitalize on low cost, locally available ingredients. Ultimately, we will collectively enhance the competitiveness of beef production systems through discovery and innovation in beef systems.

Literature Cited

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