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THE ECONOMIC EVALUATION OF BEEF CATTLE PRODUCTION ON PASTURE USING ANNUAL EQUIVALENT CASH FLOWS

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THE ECONOMIC EVALUATION OF BEEF CATTLE PRODUCTION ON PASTURE USING ANNUAL EQUIVALENT CASH FLOWS

It is a very well known fact that changes in the stocking rate affect the amount of body weight produced by beef cattle per unit of surface. Many researchers in the field have conducted experiments related to the subject. Summaries of the results obtained can be found in Mott 1/, Gray 2/ and others. The general conclusion of these studies is that: as the stocking rate increases, the total output per unit of surface increases up to a maximum point and after that, decreases very rapidly. At the same time the output per animal is almost constant during the first stages, decreasing later, before the output per unit of surface reaches a maximum (see Figure 1). In other words, an increase in stocking rate produces at the same time (shaded region):

> An increase in output per unit of surface, and
>
> A decrease in output per animal. The daily gain per animal diminishes.

Which, then, is the best solution for the producer? If the objective is to produce the greatest amount of body weight per animal, the correct selection would be point A. If the objective is to produce the greatest amount of body weight per unit of surface, then the selection would be point B. But what if the objective were to maximize profit per unit of surface and unit of time? Then neither of these two solutions would answer the question. There is a lack of information with which to make this selection. Nevertheless, some suggestions have been made. C. P. McMeekan, during the opening session of the Eighth International Grassland Congress, said:

> In practice, it is our task, in seeking maximum production from grassland within any particular system of animal production, so to manipulate the grazing factor that the maximum yield of animal products is obtained without upsetting adversely the equilibrium of the pasture complex. 3/

Conway said:

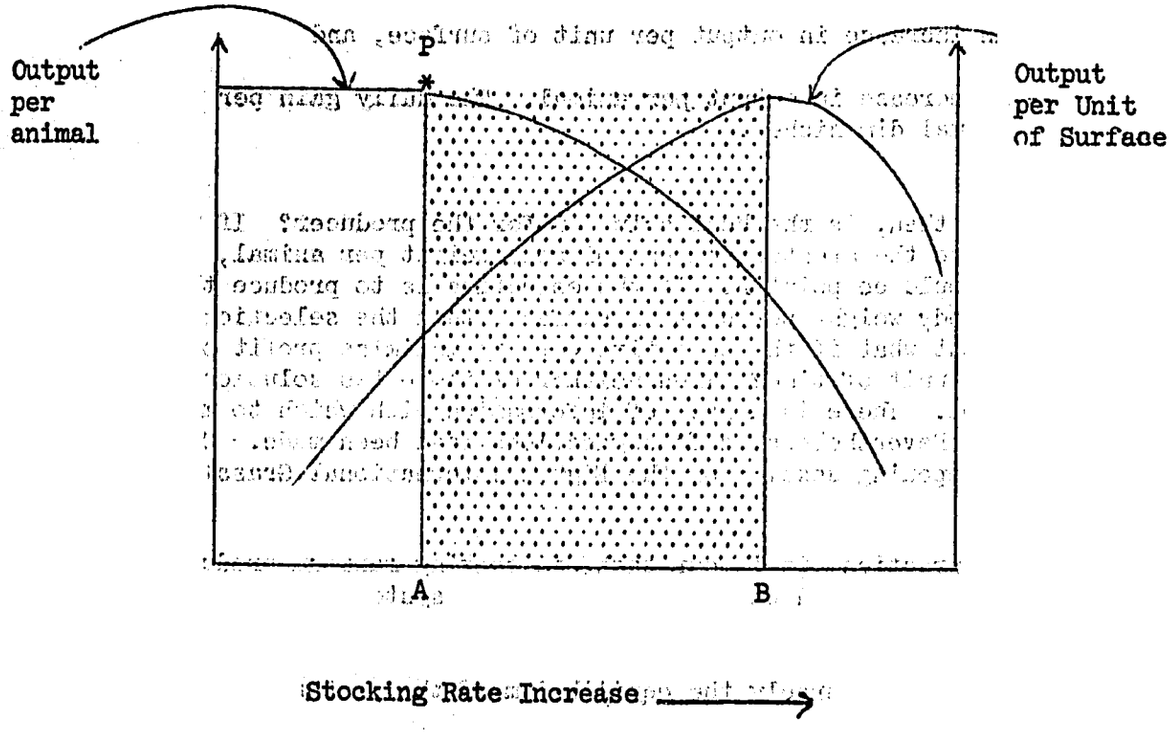
> The important measure of production from grassland is the output of high quality animal product per unit area. The maximum output of animal product per acre can only be obtained by raising the stocking rate to the optimum, i.e.

1/ G. O. Mott, "Grazing Pressure and the Measurement of Pasture Production." Proceedings of the Eighth International Grassland Congress (1960), pp. 606-611.

2/ J. M. Gray, Ranch Economics (Ames: The Iowa State University Press, 1968).

3/ C. P. McMeekan, "Grazing Management," Proceedings of the Eighth International Grassland Congress (1960), p. 21.

FIGURE 1.--The relationship between output per animal and output per unit of surface with increasing stocking rate.



Source: W. F. Raymond, "Grassland Research and Practice," Journal of the Royal Agricultural Society of England, 29 (1968), 94.

> to the state where the depression in production per animal is so great that there is no further increase in production per acre. 4/

Without doubt, both authors are suggesting point B, the best solution for the maximization of production, per unit of surface, but they do not give any consideration to some important economic factors.

Conway some years later recognized this fact, when he said: "Increasing the stocking rate increases production per acre but eventually reduces production per animal, and this may not always be desirable." 5/

Raymond pointed out that:

> . . . this increased output per acre is being achieved with animals that are themselves progressively less efficient; the challenge to research and to practice is to develop methods of utilizing forage at high intensity (point B) by animals that are at high levels of production (point P). 6/

Obviously there are different positions. Many researchers in the field agree with McMeekan and Conway (1963), while others have the same doubts that Conway had in 1970. Still there are some, who, like Raymond, believe that something is not quite right and who are consequently trying to find a solution.

Most researchers recognize that when the output per unit of surface increases to near the maximum point, the daily gains diminish; yet, they fail to consider the important consequence of this statement: the amount of time spent by the animal in arriving at the finishing weight increases as the daily gain diminishes. Consequently, the land is going to be occupied for a longer period of time, the capital invested in the calf is going to be used for a longer period of time, more monthly salaries are going to be paid to the labor force, and, finally, the money to be received by sale of the steer will be delayed.

If all of these factors (land, capital invested, monthly salaries, etc.) are occupied or used for longer periods of time, the cost of using them increases (money outflows). Also, the producer loses their availability for other cycles of production. The latter situation diminishes the revenue (money inflows), reducing even more the profits (cost subtracted from revenue).

4/ A. Conway, "Effect of Grazing Management on Beef Production. 1, Comparison of Three Stocking Rates Under Two Systems of Grazing." Irish Journal of Agricultural Research, 2 (October, 1963), 243-258.

5/ A. Conway, "Grazing Management for Beef Production," Journal of the British Grassland Society, 25 (March, 1970), 85-91.

6/ W. F. Raymond, "Grassland Research and Practice," Journal of the Royal Agricultural Society of England, 129 (1968), 85-105.

This situation has been indirectly shown by some authors like Launchbaugh 7/ who by introducing economic considerations have shown that moderate-to-light stocking rates are more profitable than heavy stocking rates.

If the goal is to maximize profits per unit of surface of land and unit of time an analytical technique which takes into consideration these variations in costs, revenues, and profits, has to be developed.

Since variation in the time that the animal spends on the pasture is a cause of the changes in profits, a technique of analysis used to evaluate investment alternatives with unequal lives will be an appropriate approach to solve the problem.

Annual Equivalent Cash Flows

There are three well known possible ways to analyze investment alternatives with unequal lives: (1) common terminal date, (2) continuous replacement cycle, and (3) annual equivalent cash flows. 8/

The annual equivalent cash flow method is the most appropriate one for handling the cattle feeding problem.

The implicit assumption is that for a given amount of land the producer will be able to continue with the same method of production, time and time again, until a total common terminal date of production is achieved. It is a comparison between cycles of production.

The basic two steps to follow under this approach are:

1. Determining the net present value per unit of surface of land (present value of inflows minus present value of outflows) of each production alternative over the period that each fattening process lasts.

2. Converting the net present value per unit of surface of land of each production alternative into net annual equivalent cash flow represents the amount of profit produced by each production alternative per unit of surface of land per unit of time (year).

The decision criterion in this case, in which the inflows (revenues) as well as the outflows (costs) are affected by time, is to select the production alternative which provides the highest net annual equivalent cash flow per unit of surface of land (profits per unit of surface of land per unit of time).

7/ J. L. Launchbaugh, The Effect of Stocking Rate on Cattle Gains and on Native Shortgrass Vegetation in West-Central Kansas (Hays: Kansas Agricultural Experiment Station Technical Bulletin 394, November 1957)

8/ R. D. Aplin and G. L. Casler, Evaluating Proposed Capital Investments with Discounted Cash Flow Methods (Ithaca, N. Y.: Department of Agricultural Economics, Cornell University, 2nd ed., 1969).

The basic equations used to determine the present value of the inflows and outflows are: 9/

1. $A_i = C_i/R^{t_i}$ (1)

where

A_i is the present value of the flow C_i

C_i is the flow to be paid or received in the future

R is equal to $(1+r)$ when the interest is compounded once a year and r is the nominal interest rate; or equal to $(1+r/q)^q$ when the interest is compounded more than once a year, r is the nominal interest rate and q is the number of times the interest is compounded in one year.

t_i is the period of time between the present and the moment in which C_i is received or paid in the future expressed in years

m is the number of flows for each production process

This equation (1) is used for flows to be paid or received once in each production process or for flows which are not received or paid at equal intervals of time (i.e., outflow of buying the calf, inflow of selling the steer).

2. $B_j = D_j(1-R^{-T})/(R^{1/P_j}-1)$ $\quad j=(1, 2, \ldots n)$ (2)

where

B_j is the present value of the flows D_j

D_j is the flow to be paid or received at the end of equal intervals of time in the future as long as the production process continues

T is the total amount of time that the production process lasts expressed in years

P_j is the number of times the flow D_j is paid or received per year

n is the number of periodic flows to be considered in each production process

R is the same as in equation (1)

This equation (2) is used for flows to be paid or received periodically (at the end of equal intervals of time) during all the production process (i.e., salaries).

9/ J. H. Moore, Handbook of Financial Mathematics (New York: Prentice Hall, 1930).

The net present value of each production alternative will be:

$$F = s\left[\sum_{\substack{i=1\\ i\neq k}}^{m} A_i + s\sum_{\substack{j=1\\ j\neq k}}^{n} B_j\right] + \sum_{i=k} A_i + \sum_{j=k} B_j$$

where

F is the net present value of the production alternative. The inflows carry a positive sign and the outflows a negative sign

s is the stocking rate per unit of surface of land. It multiplies all the flows expressed on a per head basis. This has to be done to obtain the net present value on a unit of surface of land basis

k is the subscript assigned to flows expressed on a per unit of surface of land basis. In this case it is not necessary to multiply the stocking rate.

All other symbols have been explained previously.

The basic equation to calculate the annual equivalent cash flow per unit of surface of land is:

$$E = F(R-1)/(1-R^{-T})$$

where

E is the annual equivalent cash flow per unit of surface of land

All other symbols have been explained previously.

Every one of the variables in the model is important but some are of special significance:

-- The nominal interest rate per year (r). Here like in any other investment evaluation the choice of interest rate has a substantial effect in the final decision. No particular criterion of selection will be suggested but to emphasize the importance of the careful evaluation of alternatives given the possibilities of the producer.

-- Stocking rate (s) and the length of the production process (T). The functional relationship of these two variables can vary substantially from country to country, region to region, even from ranch to ranch. Pasture composition and conditions, breed of animals, starting and finishing weights, are some of the factors which can affect this relationship. The establishment of this functional relation for each case is of fundamental importance for any evaluation that is intended.

To show the relevance of the model just proposed an example will be presented. The approach to be followed shuns the selection of an appropriate nominal interest rate per year and the functional relationship between stocking rate and length of the production process. It is intended to show the general effects of using annual equivalent cash flows to evaluate various production alternatives rather than to select the stocking rate which maximizes profits in any specific situation. In this way the misleading effects of any particular choice of interest rate and functional relation between stocking rate and length of production process are avoided.

Example 10/

Description

Given a certain amount of land and various production process lengths, the ratio between the stocking rates which produce the same annual equivalent cash flows will be found. In this way it will be possible to show that a given proportion of increase in length of time of the production process causes an increase more than proportional in the values of the stocking rate to achieve the same amount of annual equivalent cash flows.

To apply the equations suggested the flows have to be classified in two groups: (1) the flows which are paid or received only once per production alternative or flows which are not paid or received at equal intervals of time during the length of the production alternative and (2) the flows which are paid or received at equal intervals of time during the length of the production alternative.

Included in the first group are the following flows:

C_1 = Steer price ($248.12/head) 11/

C_2 = Calf price ($81.12/head) 12/

C_3 = Transportation and marketing expenses ($8.12/head) 13/

To find the present value of these three flows (A_1, A_2 and A_3) equation (1) must be used.

10/ This example is an abstraction from reality and its conclusions are not from application in any one place or region. Since data was not available for only one source, several of them were used. The selection of sources was made trying to be as simple and consistent as possible.

11/ Since the value of several flows used in the sample was computed in Kansas in 1962, the price of animals are 1962 yearly average of Kansas market. The 450 Kg steer average price was used.

12/ See footnote 11. The 150 Kg calf average price was used.

13/ A. L. Newman and R. D. Snapp, Beef Cattle (New York: John Wiley and Sons, 6th ed., 1969).

The second group of flows include the following:

D_1 = non-feed costs ($1.62/head/month)

The estimation was made as follows: 14/

	$/head/month
Veterinary care	0.0804
Dues, fees, subscriptions	0.0054
Taxes on cattle	0.2055
Insurance on cattle	0.1035
Death loss	0.3168
Hired labor	0.9087
Total non-feed cost per month	1.6203

D_2 = Land rent. This value is not needed for the comparisons this example is designed for, as is shown below. But it will be very important when the purpose of the study is to select the optimum stocking rate.

To find the present value of these flows (B_1 and B_2) equation (2) must be used.

Additional Values Needed to do the Calculations

T = time of duration of the production alternative. Since the purpose of the example is to show the relations between the stocking rates when the time of duration of the production alternatives varies and the same annual equivalent cash flows are obtained, several values will be considered. These values are from 270 days (9 months) to 900 days (30 months), at intervals of 90 days (3 months).

t_1 = The inflow from selling the steer is assumed to occur at the end of the fattening period. Then $t_1 = T$

t_2 = The outflow of buying the calf is assumed to occur at the beginning of the fattening period. Then $t_2 = 0$

t_3 = The outflow of expenses for transportation and marketing is assumed to occur at the end of the fattening period. Then $t_3 = T$

14/ The cost for veterinary care; dues, fees, and subscriptions; taxes and insurance of cattle and death loss were obtained from H. H. McCoy and C. C. Hausman, Economics of Scale in Commercial Cattle Feedlots of Kansas--An Analysis of Non-Feed Costs (Manhattan: Kansas State University Agriculture Experiment Station Technical Bulletin 151, April 1967). The hired labor cost was obtained from Economic Research Service, Farm Cost and Returns, Commercial Farms by Type, Size and Location (Washington, D.C.: U.S.D.A., Agr. Inf. Bul. 230, 1963).

P_1 = The number of times the non-feed costs are paid per year is assumed to be 12

P_2 = The number of times the rent value of the land is paid per year is assumed to be 1.

$R = (1+r)$

where

r is the nominal interest rate. To show the consequences of using different interest rates, the results will be presented for two of them: five and ten percent per year. It is assumed the interest is compounded annually.

Having defined all the variables, the annual equivalent cash flows for any two stocking rates s and s' and length of the production alternatives T and T' will be

$$E = [s(A_1-A_2-A_3-B_1)-B_2][R-1]/[1-R^T] \quad (5)$$

and

$$E' = [s'(A_1'-A_2'-A_3'-B_1')-B_2'][R-1]/[1-R^{T'}] \quad (6)$$

Since

$$B_2 = D_2[1-R^{-T}]/[R-1] \quad (7)$$

and

$$B_2' = D_2[1-R^{-T'}]/[R-1] \quad (8)$$

It is possible to replace (7) and (5) and (8) in (6) and simplify to obtain:

$$E = [s(A_1-A_2-A_3-B_1)[R-1]/[1-R^{-T}]) - D_2 \quad (9)$$

and

$$E' = [s'(A_1'-A_2'-A_3'-B_1')[R-1]/[R^{-T'}]) - D_2 \quad (10)$$

Equating both annual equivalent cash flows and simplifying, the following equation is obtained:

$$s(A_1-A_2-A_3-B_1)/[1-R^{-T}] = s'(A_1'-A_2'-A_3'-B_1')/[1-R^{-T'}] \quad (11)$$

Now, it is possible to find the ratio $R_{TT'}$ between the two stocking rates as follows:

$$R_{TT'} = s/s' = (A_1'-A_2'A_3'-B_1')[1-R^{-T}]/(A_1-A_2-A_3-B_1)[1-R^{-T'}] \quad (12)$$

The ratio $R_{TT'}$ will represent the relation which must exist between two stocking rates to have equal annual equivalent cash flows, when the time spent by the animal under the production alternative with stocking rate s is T and when the time spent by the animal under the production alternative with stocking rate s' is T'.

Results

The results are presented in Tables 1 and 2 in the following way: the number which appears in the intersection of a column with a row means the ratio that must exist between the stocking rate of the production alternative lasting the amount of time headed by the column as numerator, and the stocking rate of the production alternative lasting the amount of time headed by the row as denominator, to obtain equal annual equivalent cash flows.

Examples will illustrate the way in which the tables work. (1) At the intersection of column 540 with row 360 in Table 1 appears the value 1.67. This means that 1.67 times the stocking rate existing for the production alternative lasting 360 days is needed to obtain the same annual equivalent cash flow when the length of time of the production alternative is increased to 540 days. (2) In the same table at the intersection of column 360 with the row 720 appears the value 0.40. This means that with only 0.39 of the stocking rate existing for the production alternative lasting 720 days it is possible to have the same annual equivalent cash flows if the time of the production alternative is reduced from 720 to 360 days. In both cases the nominal interest rate considered was 5 percent.

If the nominal interest rate considered is 10 percent the values to be obtained for the two previous cases are 1.74 and 0.36. This means that for higher nominal interest rates

-- Greater increase in stocking rates are needed to obtain the same annual equivalent cash flows when the length of the production process is extended.

-- Greater reduction in stocking rates are needed to obtain the same annual equivalent cash flows when the length of the production process is lessened.

The results in Tables 1 and 2 show that as time of the production alternatives increases, the stocking rate needed to obtain the same annual equivalent cash flow also has to be increased. The increase in stocking rates has to be proportionally greater than the increase in length of time.

Conclusions

Stocking rate increases (within certain limits) have been suggested in the past to increase production of cattle per unit of surface of land, regardless of the increase in length of time of the fattening process that will result as a consequence of reducing the daily rate of body-weight gain.

It has been shown by way of an example that as the length of time of the production alternatives is increased in a given proportion, the stocking rate has to be increased more than in such a proportion to maintain the same level of profits per unit of surface of land per unit of time.

TABLE 1.--Necessary stocking rates ratio to have equal equivalent cash flows when the length of the fattening process changes, for a nominal interest rate of 5 percent compounded annually.

	T' \ T	Length of the Fattening Process (Days)							
		270	360	450	540	630	720	810	900
Length of the Fattening Process (Days)	270	1	1.40	1.85	2.35	2.90	3.53	4.25	5.07
	360	0.71	1	1.32	1.67	2.07	2.52	3.03	3.62
	450	0.54	0.76	1	1.27	1.57	1.91	2.30	2.75
	540	0.43	0.60	0.79	1	1.24	1.51	1.81	2.16
	630	0.34	0.48	0.64	0.81	1	1.22	1.46	1.75
	720	0.28	0.40	0.52	0.66	0.82	1	1.20	1.44
	810	0.24	0.33	0.43	0.55	0.68	0.83	1	1.19
	900	0.20	0.28	0.36	0.46	0.57	0.70	0.84	1

TABLE 2.--Necessary stocking rates ratio to have equal equivalent cash flows when the length of the fattening process changes, for a nominal interest rate of 10 percent compounded annually.

	T' \ T	Length of the Fattening Process (Days)							
		270	360	450	540	630	720	810	900
Length of the Fattening Process (Days)	270	1	1.43	1.91	2.48	3.15	3.94	4.89	6.07
	360	0.70	1	1.34	1.74	2.21	2.76	3.43	4.26
	450	0.52	0.74	1	1.30	1.64	2.06	2.56	3.17
	540	0.40	0.57	0.77	1	1.27	1.59	1.97	2.45
	630	0.32	0.45	0.61	0.79	1	1.25	1.56	1.93
	720	0.25	0.36	0.49	0.63	0.80	1	1.24	1.54
	810	0.20	0.29	0.39	0.51	0.64	0.80	1	1.24
	900	0.16	0.23	0.32	0.41	0.52	0.65	0.81	1

This means that changes in stocking rates which result in changes in the length of time of the fattening process have to be carefully evaluated because the reduction in profit caused by the increase in the length of time of the production process can offset the increase in profit caused by the greater production obtained as a result of higher stocking rates.

The annual equivalent cash flow technique appears to be suitable for this kind of analysis and its use is recommended when the goal is to maximize profit per unit of surface of land per unit of time.