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A Simulation Model for Assessing Alternate Strategies for Beef Production with Land, Energy and Economic Constraints

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ABSTRACT

A computer model has been developed to analyze alternate management strategies and energy and economic constraints. Daily production of beef animals and growing crops is simulated in response to prevailing conditions and system interactions using the GASP IV simulation language. Complete inventories of plant dry matter, animal status, production resources and economic net worth are maintained over the simulation period.

INTRODUCTION

The Kentucky BEEF model is an interdisciplinary effort that allows users to effectively evaluate the consequences of resource allocations and management decisions on plant and animal production, energy consumption and economic return.

The farm manager is influenced by many factors when determining a management strategy. These include land, money, animals, fertilizer, fuel, labor, market conditions and other similar types of resources. The manager develops a mental image or "model" of how these resources will interact over his planning period. He then selects a set of management strategies that will best satisfy his management objectives as he envisions the system to function. During his career, he may make 50 sets of management strategies. With each year of experience, he refines his mental model. However, he may complete his career without ever having an accurate picture of how the various system components function together. Agricultural researchers and extension specialists are faced with a similar situation. They must make decisions based on the best information available, even though their "model" may be incomplete. With this situation in mind, the computer simulation BEEF (Beef, Energy and Economic evaluation for Farms) was developed.

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BEEF is the result of an interdisciplinary effort by a team of researchers from the Departments of Agricultural Engineering, Animal Science, Agricultural Economics and Agronomy. The project was funded in part by the National Science Foundation (Walker et al., 1977 a, b, c). The objective of the research team was to provide a management, planning and teaching tool for researchers, extension specialists and farmers, capable of determining the consequences of various management and research strategies on production. The objective of this paper is to describe the functions and capabilities of the Kentucky BEEF model.

MODELING TECHNIQUE

The BEEF model is a combination continuous-discrete simulation that utilizes FORTRAN IV with the GASP IV simulation language (Pritsker, 1974). The BEEF model contains more than 4,000 source statements and has a total length of approximately 8,000 cards. BEEF requires more than 600 K bytes of computer memory storage and costs approximately one cent per field per simulated day, depending on the number of output options. Presently, BEEF is submitted in batch form. However, some of the subsystems are also used as separate interactive models.

The Systems Dynamics approach is used for the continuous portions of the model such as plant and animal growth (Forrester, 1968; Walker et al., 1977b). This approach defines daily rates of growth and utilization of a system component. The growth rate is added to the existing level of the component, while the utilization rate is subtracted. For example, the daily growth rate of a particular forage is influenced by soil fertility, soil pH, cultural practices, etc., while the utilization rate is a function of cattle size, number, and similar factors (Fig. 1). The net effect of these rates, when added to the existing dry matter level on a particular day, gives the dry matter level on the following day.

Discrete activities include scheduling of cultural practices, such as planting or harvesting, and the purchase or sale of resources. A discrete activity occurs instantaneously. That is, at one point in time a purchase is made or the planting of a crop begins. However, the activity may continue over several days after initiation of the activity as is the case with planting a crop.

The BEEF model utilizes a "field" as the area where management activities are directed. A field is defined as a homogeneous land area where any specified management activity occurs over the entire area. For example, if the planting of a crop is scheduled, it must occur over the entire field. There is no limit as to field size.

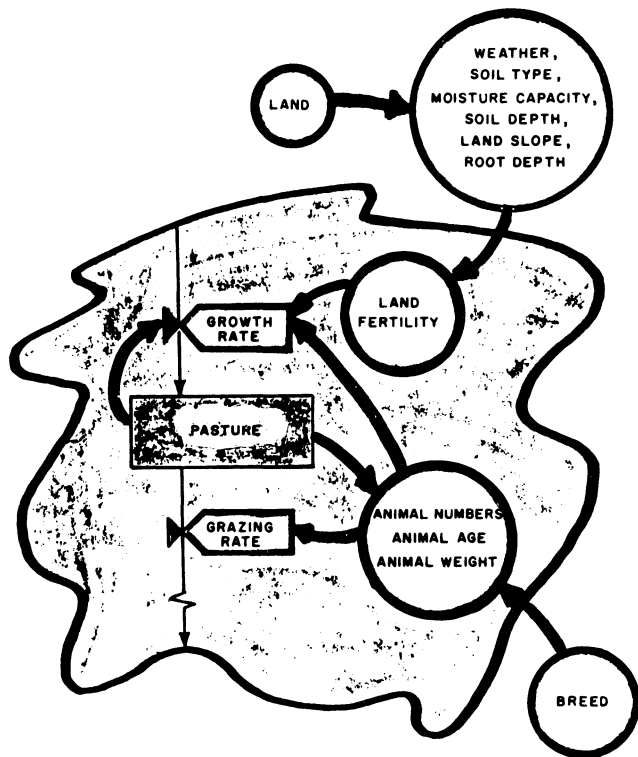


FIG. 1 Example of levels and rates.

Because BEEF can be used for planning future activities (e.g., a planning model) it utilizes average weather data in determining crop and animal performance, and has no stochastic processes. However, a period of stress conditions, such as drought, may be imposed by the model user to evaluate the performance of the system under adverse conditions.

BEEF is a "consequences of action" type model; that is, the user may specify almost any set of management decisions and BEEF will determine the consequences of these actions with regard to physical and economic happenings. No judgement is made concerning the desirability or logic of the management decisions; rather the philosophy of BEEF is that "desirability" will be reflected in physical performance and economic return.

The model user specifications take two forms: resources and management (Fig. 2). The resource specifications describe the "capital" available for management at the beginning of the simulation. The management specifications indicate how the existing resources will be used and modified through future production, purchases and sales. Each management specification includes the year, month and day on which the action will occur, and the work rate, field location and other parameters that further describe the management decision. BEEF, through the GASP IV simulation language, carries out the management decisions in sequential order utilizing the resources available at that point in simulated time.

BEEF is divided into four major subsystems: crop growth, animal growth and reproduction, economic activities, and energy. These subsystems are described in great detail by Walker et al. (1977a, b, c), including all the references cited and the numeric relationships used in evaluating alternative management strategies. These relationships were entered into BEEF as "analyst input" data meaning that numeric values of the various input

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FIG. 2 Specifications that may be made by the BEEF model user.

coefficients can be updated as better and more complete information is obtained from other research projects. The analyst input sector also allows the model user to determine the sensitivity of the model to an individual input.

CROP CROWTH

The model, as it is presently constructed, can simulate the growth of 28 different crops and crop mixes that are produced in the cool-season grass regions. The number and kinds of crops can easily be changed to adapt the model to any geographical region. A set of equations is used to describe the normal growth rate during the normal growing season for each crop planted in each field in the best soil in the geographical region supplemented with recommended production practices. During the simulation, these growth rates are modified according to each of the various operations previously specified by the model user.

The operation that result in modification of the normal growth rates of crops are as follows:

1 Tillage operations: The simulator monitors the management input specifications for each field and records if the field has been tilled and the timing and method of tillage. This information is used to determine the appropriate growth rate modifier at the time when a crop is planted.

2 Planting operations: The analyst input sector stores the normal length of growing season, the time delay for emergence, and the planting date, planting method, and row spacing growth rate modifiers for each crop. When a planting operation is scheduled, the simulator selects the time when the crop will start grow-

ing and appropriate growth rate modifiers for date of planting, method of planting, and row spacing. This analyst input information would vary with geographical area.

3 Fertilizer application operations: Growth rate is also affected by the available nitrogen, phosphorus, and potassium. The use rate of each element by each crop per unit of dry matter produced, and the quantity of each element that is adequate for normal growth are stored in the analyst input data. Equations are used to calculate the loss of nitrogen due to leaching as a function of the time of the year. The simulator maintains an accounting of the quantity of each element in the soil according to amount applied, amount used by the growing crop, and amount lost. As long as the quantity in the soil is adequate, the growth rate modifier maintains a value of 1.0, but when the quantity is below the adequate level the simulator selects an appropriate growth rate modifier.

4 Lime application operations: Growth rate modifiers for each crop for different values of soil pH are stored in the analyst input data as are the changes in soil pH per ton of lime added to different types of soil. The simulator maintains an accounting of the soil pH in each field according to the amount of lime applied and determines the appropriate growth rate modifier as a crop is growing.

5 Chemical application operations: Growth rate modifiers for weeds and insects vary according to the time during the growing season when these pests affect the growth rate of each crop. The simulator records the kind of chemical specified by the model user and when it is applied on each field. If the time arrives when a certain pest will begin to affect the growth rate of the growing crop and a chemical has not been applied that will control the pest, the simulator will select the appropriate growth rate modifier and use it during the time interval when the pest affects crop growth.

6 Row crop cultivation operations: Weeds can be controlled by cultivation and/or herbicides. Before the simulator selects a growth rate modifier for the effect of weeds, it will check whether row crop cultivation has been performed on the field.

7 Pasture maintenance operations: Cool-season grass pastures may be clipped once or twice each year to maintain the grass in the vegetative growth stage, control weeds, and reduce competition when legumes are interseeded into the pastures. The simulator adjusts the growth rate to the vegetative stage and adjusts accordingly the nutrient content of the growing crop for beef animals each time a pasture clipping operation is scheduled on a field.

8 Harvesting operations: Harvesting operations on cool-season grasses and legumes cause the growth rate and nutrient content of the growing crop for beef animals to revert to the vegetative growth stage. On the other hand, harvesting operations on grain crops cause the growth rate to become zero and the crop disappears from the field, leaving crop residue which has a negative growth rate, i.e., a loss rate. The simulator adjusts the growth rate and nutrient content of the growing crop and crop residue each time a harvesting operation is scheduled to harvest a crop. The simulator also maintains an accounting of the crop that is harvested as it is placed in storage to be fed or sold. Losses of dry matter and nutrients during harvesting and storage are also ac-

counted for by the simulator.

9 Animal moving operations: Beef animals may be moved by the model user from field to field during the year to utilize growing crops by grazing. Grazing beef animals are constantly harvesting the growing crop and consequently have an effect on the crop growth rate and nutrient content. When the quantity of growing dry matter reaches a certain minimum level, the growth rate of the crop is reduced because of the reduction in leaf area to intercept solar energy. The simulator determines the rate of consumption of growing dry matter by the grazing animals and maintains an accounting of the quantity of growing dry matter for each crop on each field. When the grazing animals reduce the quantity of growing dry matter below a certain minimum level, the simulator reduces the growth rate linearly as the quantity of dry matter is reduced. The simulator maintains an accounting of the nutrient content for beef animals of the growing crop. When the quantity of growing dry matter is reduced to a fixed minimum level by grazing animals, the nutrient content reverts to the vegetative growth stage of the growing crop. When the end of the growing season for each crop is reached, the simulator imposes a linear natural loss rate, i.e., a negative growth rate, which diminishes the dry matter left on each field from a previous growing season. The simulator also maintains an accounting of the number, age, sex, reproductive status, and weight of the animals which are grazing the growing crop on each field (Smith et al., 1977a, b).

ANIMAL GROWTH AND REPRODUCTION

Beef animals have been identified by 12 different categories for the purpose of simulating their growth and reproduction. These categories serve to group the animals according to age, sex, and reproductive status. The simulator maintains for each field an accounting of each category for the number of animals, their weighted average age and average weight per animal. The number of animals in each category on each field can change because of age, breeding, animal moving, birth, death and castration. For example, calves reach 12 months of age and become yearlings, non-pregnant cows are bred and become pregnant cows, animals are moved onto or away from a field, calves are born, death occurs, and castration of male animals is scheduled.

The simulator changes animals from one category to another based upon its accounting of the age of each category and the instructions given in the input specifications concerning breeding, animals moving, and castration. The number of animals in each category are adjusted each time a change is made.

The simulator maintains an accounting of the average age of the animals in each category on each field by chronologically updating the age each day. The average age of the animals in each category on each field can also be changed, owing to animals being moved into categories, by birth of calves, breeding, moving animals from one field to another, castrating male animals, and reaching an age that transfers animals to another category. When animals are moved into each category on each field the simulator computes a new weighted average age for each category on each field and continues the chronological updating of age.

Breeding is initiated when yearling and/or mature bulls are scheduled by the input information to be moved

onto a field with heifers and/or non-pregnant cows, and when artificial insemination is scheduled. Each category of bulls and method of artificial insemination has a characteristic breeding rate, i.e., number of females covered per day, and the simulator computes a breeding rate based upon the number of bulls and cows of each category on each field. The simulator maintains an accounting of the number of heifers and non-pregnant cows that are available for breeding, taking into account a time delay after calving before lactating cows are available for breeding and that yearling heifers have to reach a certain age and weight before they are available for breeding. The simulator also computes the daily rate of gain or loss of weight per animal for each category of female animals that is available for breeding on each field. If the female animals are losing weight, their rate of conception is reduced in proportion to the rate of weight loss. The simulator uses the bull breeding rate, the number of females in each category that are available for breeding, and the rate of gain or loss of weight per female animals in each available category to compute a conception rate for each female category that is available on each field for breeding. Females that conceive are moved into either the pregnant, non-lactating category and/or the pregnant, lactating category. At the time when the conceived females are moved into the pregnant categories, the simulator creates an unborn calf category, and maintains an accounting of the weighted average age of this category. When the age of the unborn calf category is equal to the gestation period, the calves are born and moved into one of the calf categories.

Animal growth is represented by live weight per animal, and growth rate by the rate of change in live weight as a function of time, i.e., gain or loss of weight per animal per day. The model uses input specifications describing feeding and grazing schedules and castration and health care options. Equations and analyst input data describe dry matter demand, dry matter intake, nutrient content of consumed dry matter, and the utilization of consumed dry matter for body maintenance, lactation, and gain (NRCCAN, 1969). These factors are used to simulate the change in live weight of each category of animals on each field as a function of time. The live weight per animal for each category on each field is updated each day of the simulation.

Dry matter demand is based upon the average age of the animals in each category and the potential weight per animal for animals of this age. The potential weight-age relationship for each category of animals are stored in the program. The simulator maintains an accounting of the average age of the animals in each category on each field and selects the weight per animal from the potential weight-age relationship for each category. This weight is used to compute the dry matter demand for each category of animals on each field each day.

Dry matter intake by each category of animals on each field is based upon the dry matter demand, the quantity of dry matter available, the metabolizable energy content of the available dry matter, the incidence of diseases and parasites among the animals, and the mean daily temperature and relative humidity. The simulator maintains an accounting of the dry matter demand for each category of animals on each field. Analyst inputs provide the metabolizable energy content of stored dry matter that is fed, and the simulator maintains an accounting of

the metabolizable energy content of the dry matter that is available for grazing. Analyst input data provide reduction factors to reduce the dry matter intake due to the incidence of diseases and parasites for each category of animals and at the times during the year when each disease and parasite affects dry matter intake. Input specifications describe whether health care operations are scheduled at the proper times to prevent diseases and control parasites. Analyst input data provide the annual distribution of mean daily temperatures and relative humidities, and the simulator uses an equation to compute a reduction factor to reduce the dry matter intake when the temperature and relative humidity are above certain levels.

The model simulates dry matter intake by each category of animals on each field using the following procedure:

- 1 If the amount of dry matter available is equal to or greater than the dry matter demand, the dry matter intake is equal to the demand or the amount which satisfies the need of each category for metabolizable energy, whichever is smaller. When several different kinds of dry matter are available, the amount of intake of each kind is based upon its quantity and metabolizable energy content.

- 2 If the amount of dry matter available is less than the dry matter demand, the dry matter intake is equal to the amount available or the amount which satisfies the need of each category for metabolizable energy, whichever is smaller.

- 3 The dry matter intake, according to 1 or 2 above, is reduced by modifiers for the incidence of diseases and parasites and for high levels of temperature and relative humidity.

The dry matter that is consumed by each animal category on each field is utilized by the animals for maintenance of body functions and weight, lactation, and gain in body weight. The simulator determines each day the quantity of dry matter needed by each category of animals for each of these physiological processes, and compares the need with the amount consumed. The dry matter needs are based upon metabolizable energy, digestible protein, and the metabolic body weight of the animals (Lofgreen and Garrett, 1968). If the needs for the body maintenance and lactation are satisfied, then any excess available dry matter is utilized to provide gain in body weight. Conversely, failure to satisfy the needs for body maintenance and lactation results in loss of body weight. Analyst input data provide inflation factors that may be used to increase the dry matter needs for maintenance of body functions and weight due to the incidence of diseases and parasites for each animal category, and at the times during the year when each disease and parasite affects utilization of dry matter. Input specifications describe whether health care operations are scheduled at the proper times to prevent diseases and control parasites. A detailed description of the animal growth and reproduction portion of BEEF is given by Smith et al., 1977b and Loewer et al., 1980.

ECONOMIC ACTIVITIES

The BEEF model allows the user to make economic decisions in much the same way as he would do under actual conditions. The model user may alter the cash flow of the farm by scheduling of notes (payable or receivable)

ACCOUNT ID.	AVAILABLE MONEY	INTEREST RATE (%)	MONEY REMAINING	INTEREST DUE	CURRENT LOAN BAL.	CUM. AMT. BORROWED	CUM. AMT. INTEREST
1	5000.00	0.0	-667.35	0.0	5667.35	18269.58	0.0
2	5000.00	4.50	4236.98	155.56	763.02	0.0	125.55
3	50000.00	8.00	49910.48	0.0	89.52	5658.08	6.77

FIG. 3 Money accounts.

and miscellaneous income and expenses. He may purchase or sell his resources, and an income and net worth statement are prepared for him. Expected prices for resources that are either purchased or sold are set by the model user.

Money Accounts

BEEF contains three types of money accounts: checking, savings and loans (Fig. 3). Each account contains a quantity of money specified by the user. The checking account has no interest rate associated with it. The interest rates for the savings and loan accounts are specified by the user. However, only one savings account is allowed while the user may borrow from up to seven separate loan accounts. In addition, the user may automatically control the flow of money among accounts by specifying the high and low limits of checking and savings accounts. For example, one of the options is to set limits on his accounts so that if the checking account is overdrawn, money is automatically transferred from savings to checking. When the savings account is overdrawn, money flows to it from the loan accounts.

When a purchase is made, the user must designate the account that will be used for payment. If a loan account is used, interest will accumulate on the unpaid balances. Likewise, the account that will receive money from a sale must be specified. If a loan account receives money, the interest is paid first followed by the principle. Any additional money from the sale flows into the checking account.

Miscellaneous Income and Expenses

The user may specify a schedule for miscellaneous income and expense over the simulation period. For example, if the model user wishes to consider income from a part-time job as part of the cash flow in his analysis, he would specify the quantity of money involved and the time that the money would be added to the user specified account.

Notes Payable and Receivable

The user may specify notes, either payable or receivable. A schedule of payments is established by the user including the money account to which the note will be paid or received. Interest paid or received is computed internally as is the present value of the note. The notes payable and receivable section (Fig. 4) allows the user to account for debts incurred before the simulation period begins.

NOTE ID	TIME FIRST PAYMENT	INTEREST RATE (%)	ACCOUNT ALTERED	PAYMENT AMT. (\$)	REMAINING PAYMENTS	DAYS BETWEEN PAYMENTS	PRINCIPAL (\$) INTEREST	CUM. AMT INTEREST
1	364.00	6.00	1.0	2500.00	19.00	365.00	27895.14	1720.48
2	364.00	8.00	1.0	2400.00	2.00	365.00	4279.92	494.80
3	364.00	8.00	1.0	1600.00	0.0	365.00	-3.00	114.52
4	364.00	8.00	1.0	1200.00	2.00	365.00	2139.91	247.40
5	364.00	8.00	1.0	300.00	1.00	365.00	277.78	42.80

FIG. 4 Notes payable.

CATEGORY OF EXPENSE/INCOME	EXPENSE, \$	INCOME, \$	NET, \$
1 TAXES	589.62	0.0	
2 LABOR	7158.03	0.0	
3 INSURANCE	77.73	0.0	
4 INTEREST	2630.77	105.60	
5 CUSTOM OPERATION	1419.79	0.0	
6 HEALTH PRACTICES	0.0	0.0	
7 CATTLE	0.0	4629.48	
8 GRAIN	0.0	10085.21	
9 HAY	0.0	0.0	
10 SILAGE	0.0	0.0	
11 HAYLAGE	0.0	0.0	
12 FERTILIZER	3701.25	0.0	
13 LIME	0.0	0.0	
14 SEED	409.50	0.0	
15 CHEMICALS	270.00	0.0	
16 FUEL	376.62	0.0	
17 PROTEIN	97.30	0.0	
18 MINERALS	53.44	0.0	
19 VACCINE	0.0	0.0	
20 MEDICINE	0.0	0.0	
21 SEMEN	0.0	0.0	
22 REPAIRS	1024.45	0.0	
23 UTILITIES	0.0	0.0	
24 LAND	0.0	0.0	
25 MISC.	550.00	2500.00	
26 DEPRECIATION	3132.64		
TOTALS FOR EXPENSE, INCOME	21491.11	17320.29	
NET INCOME			-4170.81

FIG. 5 Income statement Jan. 1, 1978.

Purchases

All the resources required for production may be purchased at times and for amounts specified by the user. In addition, he may choose to defer payments using a uniform payment series with or without a down payment. All purchases must be charged to one of the money accounts. The delivery date of the purchased item is also specified by the user. When this date is reached by the simulation, the inventory of this item is adjusted to reflect the total quantity of the item on hand and its value.

Sales

The user may sell any resource item for any price he wishes at any point during the simulation period. The quantity sold is expressed as a percentage of the supply that is in inventory at the time of the sale. For example, the user may specify that 50 percent of the yearling heifers he has on Field No. 3 will be sold on May 20 of the simulation period for \$42.00 per hundred pounds, and the money from the sale will be placed in Account No. 3 (the loan account). On May 20 of the simulation period, 50 percent of the yearling heifers are removed from the Field No. 3 inventory. The total weight of these animals (computed internally by BEEF) is multiplied by the price and this sum of money is transferred to Account No. 3, first to pay the interest due, then to repay the principle, with the excess funds, if any, going into the checking account.

Income Statement

At the end of each simulated year an income statement is prepared (Fig. 5). This statement is developed by internally determining the total expenses and receipts over the simulated year using the cash basis of accounting. Depreciation for machinery is calculated based on user supplied machinery and depreciation method data, and is included as a deductible expense. The primary difference between this income statement and the standard Internal Revenue Service technique is that no personnel deductions are allowed for items such as the number of dependents, contributions to charity, etc.

Net Worth

Taxable income is one indicator of profitability with

TYPE	DESCRIPTION OF ITEM	UNITS	ID	NUMBER	\$/UNIT	SUBTOTAL, \$	TOTAL, \$
ASSETS	LAND	ACRES	1	45.00	518.00	23310.00	
ASSETS	LAND	ACRES	2	100.00	518.00	51800.00	
ASSETS	LAND	ACRES	3	32.00	518.00	16576.00	
ASSETS	LAND	ACRES	4	3.00	518.00	1554.00	
						<u>93240.00</u>	
ASSETS	MACHINERY	EACH	1	1.00	5378.11	5378.11	
ASSETS	MACHINERY	EACH	2	1.00	345.93	345.93	
ASSETS	MACHINERY	EACH	3	1.00	2523.08	2523.08	
ASSETS	MACHINERY	EACH	4	1.00	385.72	385.72	
ASSETS	MACHINERY	EACH	5	1.00	83.18	83.18	
ASSETS	MACHINERY	EACH	6	1.00	338.25	338.25	
ASSETS	MACHINERY	EACH	7	1.00	2495.36	2495.36	
ASSETS	MACHINERY	EACH	8	1.00	144.14	144.14	
ASSETS	MACHINERY	EACH	9	1.00	1030.80	1030.80	
ASSETS	MACHINERY	EACH	10	1.00	172.97	172.97	
ASSETS	MACHINERY	EACH	11	1.00	772.94	772.94	
ASSETS	MACHINERY	EACH	12	1.00	331.66	331.66	
						<u>14002.10</u>	
ASSETS	FERTILIZER	TONS	1	0.0	137.50	0.0	
ASSETS	FERTILIZER	TONS	2	0.0	182.50	0.0	
ASSETS	FUEL	GAL-LBS	1	512.13	0.55	281.67	
						<u>281.67</u>	
ASSETS	SFED	LBS	1	0.0	0.65	0.0	
ASSETS	PROTEIN	LBS	1	622.53	0.14	87.15	
						<u>87.15</u>	
ASSETS	MINERALS	LBS	1	467.52	0.11	51.43	
						<u>51.43</u>	
ASSETS	HAY	TONS	2	22.84	40.00	913.60	
						<u>913.60</u>	
ASSETS	GRAIN	BUSHEL	29	261.28	2.00	522.57	
						<u>522.57</u>	
ASSETS	CATTLE:FIELD NO. 2	100 LB	5	3250.25	38.00	1235.10	
ASSETS	CATTLE:FIELD NO. 2	100 LB	7	19068.57	50.00	9534.29	
ASSETS	CATTLE:FIELD NO. 2	100 LB	13	0.0	0.0	0.0	
ASSETS	CATTLE:FIELD NO. 3	100 LB	10	687.82	56.00	385.18	
ASSETS	CATTLE:FIELD NO. 4	100 LB	1	2063.10	57.00	1175.97	
						<u>12330.52</u>	
ASSETS	BANK ACCOUNTS	DOLLARS	1	1.00	0.0	0.0	
ASSETS	BANK ACCOUNTS	DOLLARS	2	1.00	3585.72	3585.72	
						<u>3585.72</u>	
TOTAL ASSETS, DOLLARS						125014.50	
LIABIL.	NOTES PAYABLE	DOLLARS	1	1.00	27895.14	27895.14	
LIABIL.	NOTES PAYABLE	DOLLARS	2	1.00	4279.82	4279.82	
LIABIL.	NOTES PAYABLE	DOLLARS	3	1.00	-0.00	-0.00	
LIABIL.	NOTES PAYABLE	DOLLARS	4	1.00	2139.91	2139.91	
LIABIL.	NOTES PAYABLE	DOLLARS	5	1.00	277.78	277.78	
						<u>34592.64</u>	
TOTAL LIABILITIES, DOLLARS						34592.64	
TOTAL NET WORTH, DOLLARS						90421.81	
CHANGE IN NET WORTH FROM BEGINNING OF SIMULATION, DECIMAL PERCENT						-0.05	

FIG. 6 Net worth.

ENERGY FOR FIELD OPERATIONS(USER APPLIED)										
FIELD	FUEL	LABOR	M.T.GR.	SEED	FERT.	LIME	CHEM.	PROTEIN	MINERAL	
1	0.2123E 07	0.1273E 05	0.6239E 06	0.1134E 07	0.1033E 09	0.0	0.4950E 07	0.0	0.0	0.0
2	0.6228E 07	0.1178E 05	0.4445E 06	0.0	0.0	0.0	0.0	0.0	0.4402E 06	0.0
3	0.3251E 07	0.4201E 05	0.1030E 07	0.0	0.0	0.0	0.0	0.4640E 06	0.7135E 05	0.0
4	0.2547E 05	0.2870E 03	0.5018E 04	0.0	0.0	0.0	0.0	0.0	0.1188E 05	0.0

ENERGY FOR FIELD OPERATIONS(CUSTOM APPLIED)										
FIELD	FUEL	LABOR	M.T.GR.	SEED	FERT.	LIME	CHEM.	PROTEIN	MINERAL	
1	0.2166E 08	0.2494E 05	0.1373E 07	0.0	0.0	0.0	0.4928E 06	0.0	0.0	0.0
2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

ENERGY FOR HERD MANAGEMENT OPERATIONS(USER APPLIED)										
	FUEL	LABOR	M.T.GR.	VACCINE	GRD.STIM.	MEDICINE	CHEM.	SEMFEN	DUMMY	
	0.2782E 04	0.6371E 05	0.1946E 06	0.1079E 05	0.3332E 04	0.0	0.7188E 04	0.0	0.0	0.0

ENERGY FOR HERD MANAGEMENT OPERATIONS(CUSTOM APPLIED)										
	FUEL	LABOR	M.T.GR.	VACCINE	GRD.STIM.	MEDICINE	CHEM.	SEMFEN	DUMMY	
	0.1240E 03	0.4500E 04	0.1915E 05	0.1797E 04	0.0	0.0	0.0	0.0	0.0	0.0

FIG. 7 Breakdown of energy usage by category.

net worth being another. An inventory of all resource items and their value per unit are maintained internally. The net worth statement (Fig. 6) reflects the values of the expendable items in inventory, the market value of machinery, the market value of land, the present value of notes and loans, and cash on hand. The change in net worth from the beginning of the simulation is also maintained.

ENERGY

The BEEF model maintains an accounting of the energy use incurred on a daily basis for owning and maintaining buildings, fences, and roads, and the energy use for each production operation as it occurs during the simulation. The energy use for production operations is identified according to the amount (Kcal) used for fuel; labor; manufacture, transport, and repair of machines; seed; fertilizer; lime; chemicals; protein supplement; and mineral supplement (Fig. 7). Analyst input data provide energy values for different methods of performing production operations and materials used in these operations; and input specifications describe when and how each operation will be performed. A complete description of the techniques used in BEEF is given by Bridges and Smith, 1979.

OUTPUT

The BEEF model has several forms of output that may be selected by the model user. These include tables, event monitoring and plots with optional tables.

Tables

BEEF has a standard output set of tables which reflect the initial conditions of the system. If other output information is desired, it must be specified by the user. Additional tables in any combination may be printed with any frequency. The types of table information include land, machinery, money accounts, notes payable, notes receivable, cattle, fertilizer, lime, chemicals, fuel, seed, protein, minerals, silage, haylage, hay, grain, cubes and wafers, growing crops, present worth, and energy factors (Fig. 8).

Event Monitoring

The BEEF model allows the user to monitor the management decisions (events) that occur over the simulation period. Field operations and herd management operations may be traced over any time period for any number of fields or categories of beef animals. Financial transactions, such as purchases or sales, may also be monitored.

Plots with Associated Tables

FORTTRAN plots with or without associated tables may be selected for energy utilization, cash flow, pasture performance, and animal performance.

The plot for energy utilization shows the components of the energy used in addition to the total quantity used over time. This allows the user to monitor any category of energy consumption, such as for fuel, over the simulation period. For example, the energy input associated with fertilizer application is highlighted in Fig. 9.

CATTLE										
FIELD ID	CATEGORY ID*	NUMBER OF ANIMALS	AVERAGE AGE(MO)	AVERAG WT.(LB)	MRKT. VALUE (\$/100 LB)	NUMBER SOLD	NUMBER PURCHASED	SALF (\$)	PURCHASE (\$)	
2	5	4.03	71.99	807.06	38.00	0.0	0.0	0.0	0.0	0.0
2	6	0.0	0.0	0.0	55.50	0.82	0.0	362.70	0.0	0.0
2	7	24.59	63.46	775.77	50.00	0.0	0.0	0.0	0.0	0.0
2	10	0.0	0.0	0.0	56.00	10.50	0.0	1724.89	0.0	0.0
2	12	0.0	0.0	0.0	64.10	12.36	0.0	2541.98	0.0	0.0
2	13	24.59	6.84	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3	10	1.85	9.04	371.28	56.00	0.0	0.0	0.0	0.0	0.0
4	1	1.00	60.00	2062.90	57.00	0.0	0.0	0.0	0.0	0.0

*1. MATURE BULLS; 2. MATURE STEERS; 3. YEARLING BULLS; 4. YEARLING STEERS; 5. NON-LACTATING NON-PREGNANT COWS; 6. YEARLING HEIFERS NON-PREGNANT; 7. PREGNANT NON-LACTATING COWS; 8. LACTATING NON-PREGNANT COWS; 9. LACTATING PREGNANT COWS; 10. FEMALE CALVES; 11. BULL CALVES; 12. STEER CALVES; 13. UNBORN CALVES.

LIME										
ID NO.*	TN ON HAND	CST(\$/TN)	BTU'S/TN	TONS USED	BTU'S USED	TONS PUR.	TONS SOLD			
1	0.0	0.0	1487999.0	0.0	0.0	0.0	0.0			
2	0.0	0.0	1487999.0	0.0	0.0	0.0	0.0			

*1=AGRICULTURAL; 2=HYDRATED.

FERTILIZER										
ID NO.	N(\$)	P205(\$)	K2O(\$)	TN ON HAND	CST(\$/TN)	BTUS/LB	TONS USED	BTU'S USED	TONS PUR.	PUR.
1	5.0	10.0	15.0	0.0	137.50	4283.45	9.00	0.7710E 04	0.0	9.00
2	33.0	0.0	0.0	0.0	182.50	12328.57	13.50	0.3329E 09	0.0	13.50

CHEMICALS										
ID NO.	TYPE	ID LB OR GAL	COST	BTU'S/LB.	BTU'S/GAL	AMT. USED (LB. OR G.)	BTU'S USED (TOTAL)	AMT. PUR. (TOTAL)	AMT. SOLD (TOTAL)	
25	0.0	0.0	0.60	43647.99	218239.94	450.	0.1964E 08	450.00	0.0	0.0

*1. PRINCEP; 2. PARAQUAT; 3. X-77; 4. BALAN; 5. 2,4-D; 6. LASSO; 7. TRIFLAN; 8. ERADICANE; 9. ATRAZINE; 10-20. HERBICIDES; 21. SEVIN; 22. PARATHION; 23. MALATHION; 24. HEPTACHLOR; 25. INSECTICIDES.

**1. LIQUID; 2. GRANULAR.

FIG. 8 Production resources.

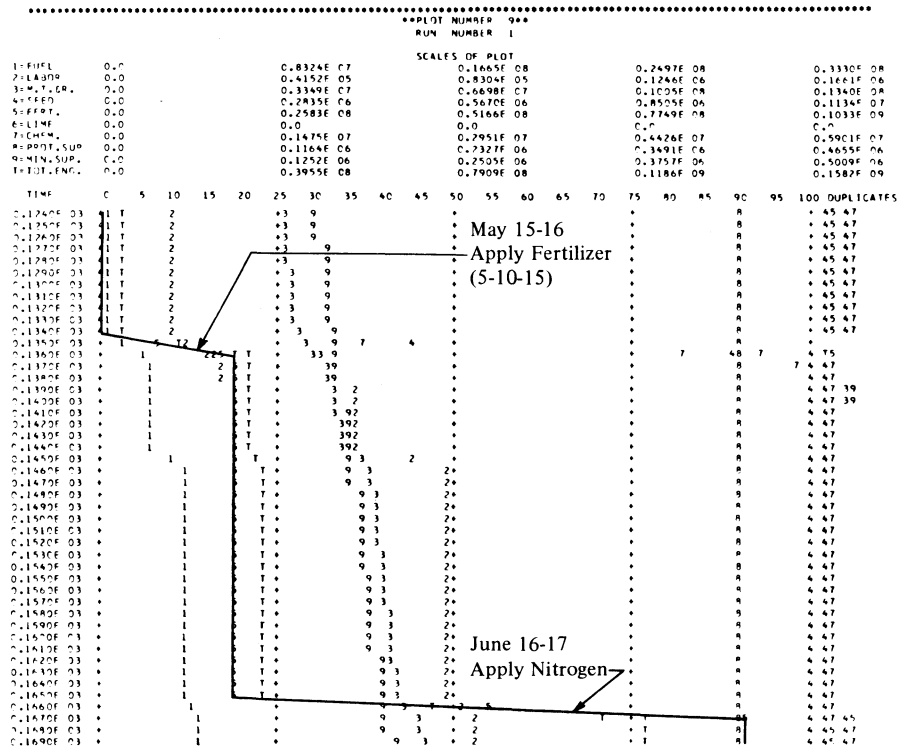


FIG. 9 Plotted output of variables related to consumption of non-renewable energy (kilocalories).

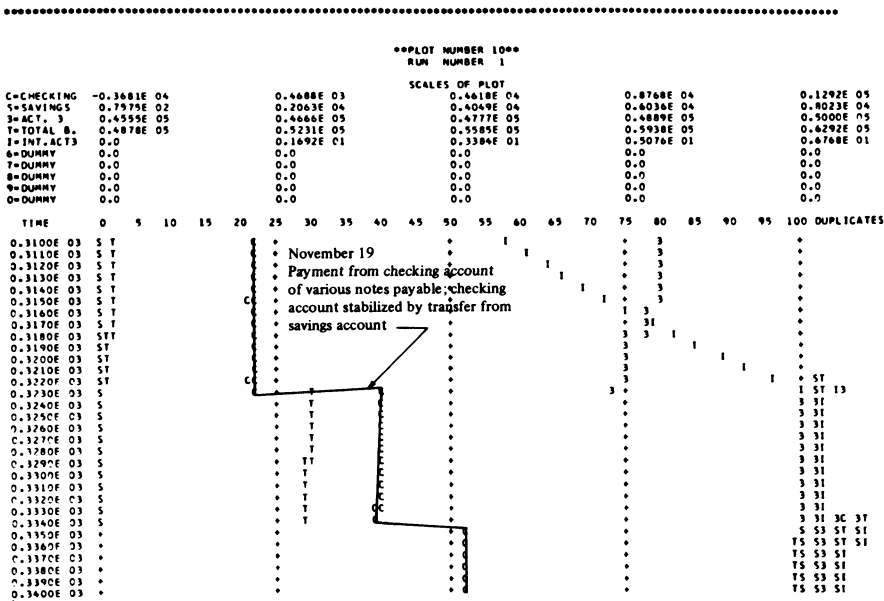


FIG. 10 Plotted output of variables related to money accounts (dollars).

The cash flow plot monitors the checking, savings and loan accounts, and the total cash available. Interest on the loan account is also tabulated. A typical transaction is highlighted in Fig. 10.

Pasture performance may be monitored for up to four fields. The dry matter level and rate of growth are presented in addition to other factors. However, no animal performance information is presented in these plots. The effects of hay harvesting on dry matter availability is highlighted in Fig. 11.

Up to four animal performance plots may be obtained. Each category of animals is monitored on a user specified field rather than added together for the cumulative effect

over the total farm. Fig. 12 highlights a reduction in gain for steer calves (category 12) because of insufficient dry matter on field no. 2.

USER INPUTS

An input booklet was prepared for the BEEF user to assist him in using the model. The book contains a complete set of input forms with detailed instructions for data entry. Each input sheet utilizes a standard FORTRAN input form so that cards may be punched directly. The complete book will require approximately 8 h to complete depending on farm size and the complexity of management strategies. However, changes in resources

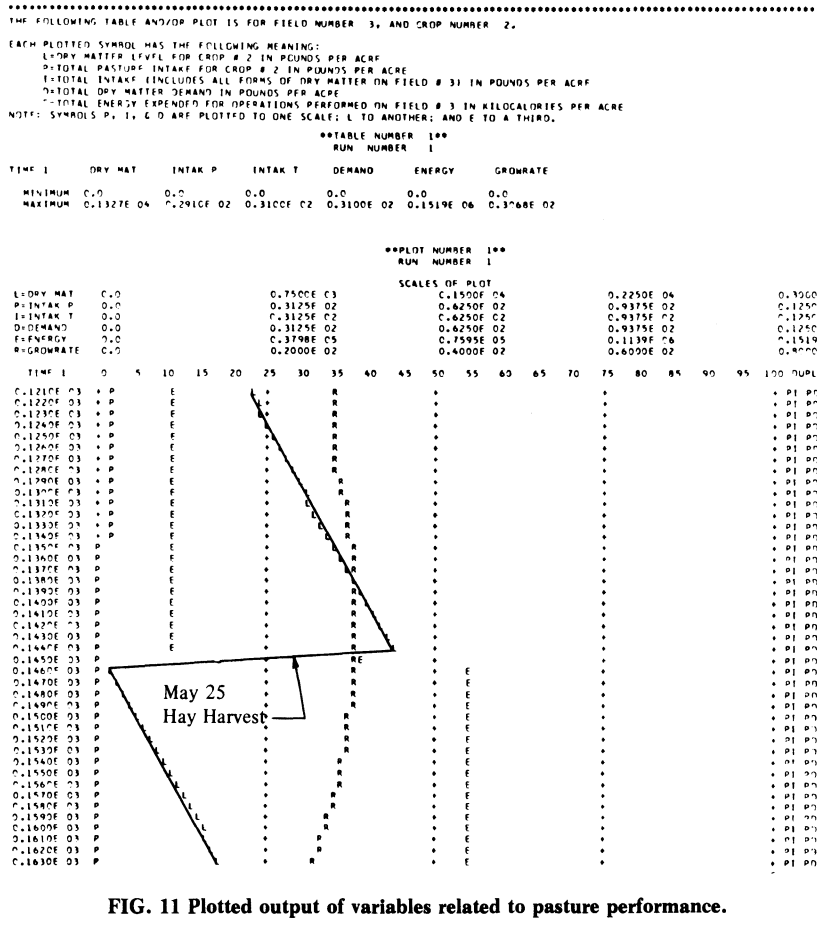


FIG. 11 Plotted output of variables related to pasture performance.

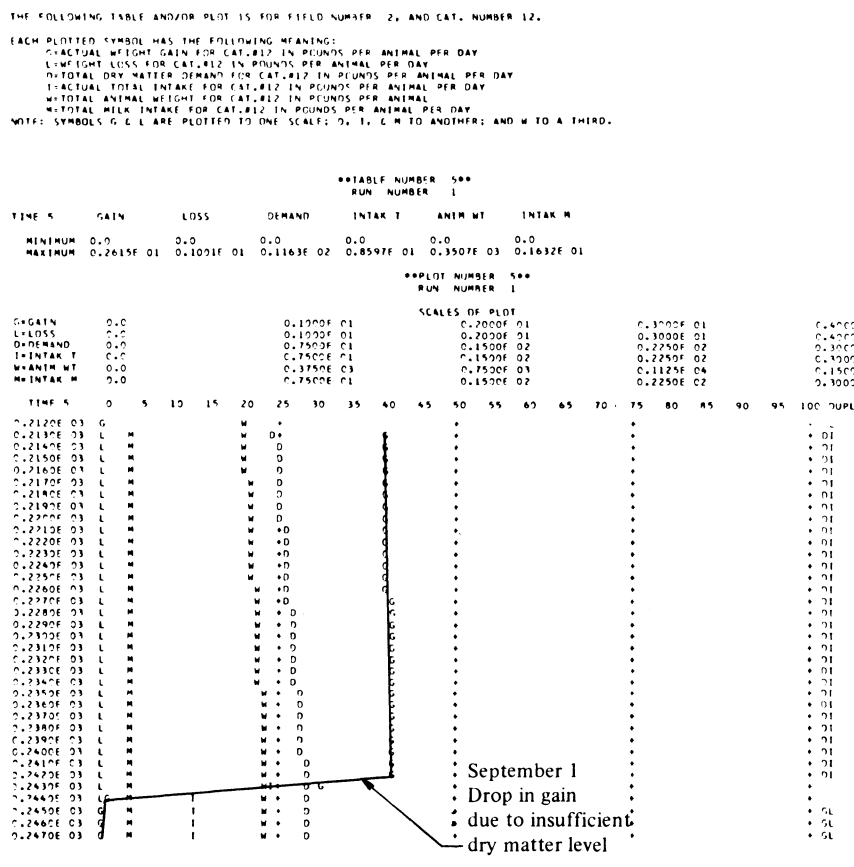


FIG. 12 Plotted output of variables related to animal performance.

or management strategies will require only minutes to input once the basic farm data is available to be used by the computer.

ANALYST INPUT

The BEEF model was developed so that it might be modified by the analyst to reflect differences in geographical areas or to test the sensitivity of the system to certain input parameters. The analyst inputs reflect our best estimates of the effects of management decisions on the production process. These estimates were obtained directly and indirectly from the literature and other researchers using both inductive and deductive reasoning to obtain the best values possible.

SUMMARY

The Kentucky BEEF model is the result of an interdisciplinary effort that incorporates the interactions of growing crops, grazing beef animals, energy utilization, and economics in a farm production system. It is a dynamic computer simulation that utilizes mathematical expressions in determining the physical cause-effect relationships among system components.

BEEF may be used by farmers to plan future management decisions or resource allocations. It may be used by extension specialists and teachers to demonstrate the benefits of sound management practices. And, it may be used by researchers to evaluate the sensitivity of the total system to subsystem interactions and components.

The BEEF model may be used as a cropping model only. Presently, beef animals are the only livestock category that may be considered by the model user. However, swine, dairy, and sheep are currently being added.

The agricultural system is a complex aggregate of subsystems, each somewhat dependent on the other. Maximizing the effect of one particular sector may reduce the functional capability of the total system. What appears to be a sound management practice may result in reduced production for reasons not readily apparent until the system component interactions are evaluated. When this

“counter-intuitive” behavior (Forrester, 1971) is analyzed, it leads to greater understanding of the system by the farmer, extension specialist and researcher. The BEEF model was developed to aid in this understanding.

References

- 1 Bridges, T. C. and E. M. Smith. 1979. A method for determining the total energy input for agricultural practices. *TRANSACTIONS of the ASAE* 22(4):781-784.
- 2 Forrester, Jay W. 1968. *Principles of systems*. Ed. 2. Wright Allen Press, Cambridge, MA.
- 3 Forrester, Jay W. 1971. Counterintuitive behavior of social systems. *SIMULATION*, February, 61-76 pp.
- 4 Loewer, O. J., E. M. Smith, G. Benock, N. Gay, T. Bridges and L. Wells. 1980. Dynamic simulation of animal growth and reproduction. *TRANSACTIONS of the ASAE* (in press).
- 5 Lofgreen, G. P. and W. N. Garrett. 1968. A system for expressing net energy requirements and feed values for growing and finishing beef cattle. *J. of Animal Science* 27:793-806.
- 6 National Research Council Committee on Animal Nutrition. 1969. *United States-Canadian tables of feed composition*.
- 7 Pritsker, Alan B. 1974. *The GASP IV simulation language*. John Wiley and Sons, New York.
- 8 Smith, E. M., O. J. Loewer, Jr., G. T. Benock, N. Gay, S. Burgess, T. C. Bridges, L. G. Wells, G. Bradford, D. Debertin, L. Springate and John Walker. 1977a. Dynamic simulation of animal growth and reproduction. ASAE Paper No. 77-4511. ASAE, St. Joseph, MI 49085.
- 9 Smith, E. M., O. J. Loewer, Jr., G. T. Benock, N. Gay, S. Burgess, T. C. Bridges, L. G. Wells, G. Bradford, D. Debertin, L. Springate and John Walker. 1977b. Dynamic simulation of plant growth interacting with grazing animals. ASAE Paper No. 77-4512. ASAE, St. Joseph, MI 49085.
- 10 Walker, J. N., E. M. Smith, O. J. Loewer, Jr., G. T. Benock, N. Gay, S. Burgess, L. G. Wells, T. C. Bridges, L. Springate, J. Boling, G. Bradford and D. Debertin. 1977a. BEEF: beef, energy and economic evaluator for farms, vol. I—discussion and results of the study. Final report of the study to the National Science Foundation, October.
- 11 Walker, J. N., E. M. Smith, O. J. Loewer, Jr., G. T. Benock, N. Gay, S. Burgess, L. G. Wells, T. C. Bridges, L. Springate, J. Boling, G. Bradford and D. Debertin. 1977b. BEEF: beef, energy and economic evaluator for farms, vol. II—discussion and listing of the model. Final report of the study to the National Science Foundation, October.
- 12 Walker, J. N., E. M. Smith, O. J. Loewer, Jr., G. T. Benock, N. Gay, S. Burgess, L. G. Wells, T. C. Bridges, L. Springate, J. Boling, G. Bradford and D. Debertin. 1977c. BEEF: beef, energy and economic evaluator for farms, vol. III—input forms for the model. Final report of the study to the National Science Foundation, October.