MINIMUM COST FEEDING SYSTEMS FOR BACKGROUNDING BEEF CATTLE IN CENTRAL KENTUCKY

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MINIMUM COST FEEDING SYSTEMS FOR BACKGROUNDING BEEF CATTLE IN CENTRAL KENTUCKY

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Techniques used to produce beef have undergone changes in recent years. These changes have been induced by increased production specialization, improved transportation, and shifts of locational advantages. Much of the red meat now consumed is finished in commercial feedlots. Demand for feeder animals by commercial feedlots has led to the development of specialized intermediate feeders, sometimes referred to as backgrounders.

There is no precise definition of backgrounding. It means different things to different producers. The basic idea, however, is to grow the animals from weaning weights to intermediate weights of 700-850 pounds, more ready for feedlot conditions. Backgrounded animals appeal to feedlot owners because the animals are already partially accustomed to feedlot environments and rations. This reduces stress during the initial days in the feedlot. Backgrounding functions include assembling the animals, the use of effective health practices, and a proper grass-forage-concentrate feeding program. Feed sources, length of the feeding period, rates of gain, beginning and ending weights vary from system to system.

How extensive is backgrounding in Kentucky? Exact data are not available on the numbers of animals being backgrounded. However, Kentucky's rate of increase in total beef animal numbers has been substantially greater than the national average (see Figure 1). Further, when Browning et al. (1973) divided Kentucky into three substate areas, they found Area 2 to have the highest rate of increase in beef numbers. Area 2 is rich in forage production and grazing of animals is a major agricultural activity. As backgrounding grows more extensive with the passing of time, it is likely to continue to be more prevalent in Area 2 than any other area of Kentucky.

Feed costs have always comprised a substantial portion of the total cost of finishing beef cattle in drylots and a fairly large proportion of the cost of producing feeder cattle (Allen et al., 1976, pp. 10-15). Indeed, feed price increases in recent years make it even more desirable that, whatever the production stage, nutritional requirements be met with low-cost feed mixes. In recent years, many drylot producers and feed manufacturers have determined their own least-cost balanced rations. Linear programming techniques have been widely used to compute these rations and to compute changes in the rations as sources of feed or feed prices change (Cooper and Steinberg, 1974, pp. 27-28). However, linear programming techniques have not been employed by producers who background cattle. This is largely due to the problem of accurately specifying the nutrient content of forages. Second, numerous systems are used to background cattle; so, to specify rations may have no continued meaning nor extensive application except for those few producers who regularly use a given system. Third, most forages have been viewed as fixed assets; i.e., they have no alternative market value.

The purpose of this report is to present recent research findings on backgrounding in Central Kentucky. More specifically, the objective is to present results on least cost feed mixes for each of nine backgrounding systems identified as commonly used and feasible. Cost efficiency of feed utilization among these systems is compared.

Feasible Systems

Three approaches were employed to

identify feasible backgrounding systems: (1) a review of past studies dealing with commonly used or recommended systems; (2) consultation with beef cattle extension specialists; and (3) a survey of selected Central Kentucky producers who background beef cattle. Information obtained from the survey was most useful.

The survey of 37 beef cattle producers was conducted in 1974 in Madison, Lincoln, Bourbon, Scott, and Harrison Counties (see Figure 1). The survey was aimed at those commercial producers who exhibited higher than average levels of management, those who presumably were not influenced to a large extent by goals other than profit maximization. These farmers were selected by the County Agricultural Extension Agents of each county.

The survey questionnaire dealt with several phases of backgrounding operations. Information collected included animal description, feed sources and quantities, dates of feeding periods, market prices of feed, conditioning practices, average daily gain (ADG), growth stimulants (if used), and description of feeding facilities.

Information from the survey was categorized according to these characteristics that, in effect, define the various backgrounding systems. These characteristics are shown as columns in Table 1. Each backgrounding system carries some degree of generalization, yet is specific enough to occur essentially as it is described in the table. The systems are classified as nonpasture systems, mixed systems, and pasture systems.

Nonpasture systems do not allow the animals access to any pastures. Three such systems are specified (Table 1). Grains, silages, hay with protein supplements and minerals are considered as possible feed alternatives. Systems 2a and 2b are fully automated. Feed equipment needs include automatic silo unloaders, feed augers, feed bunks and chains, and other feeding equipment. Since hay is not handled efficiently through automatic feeding equipment, it is considered as a possible feed source for system 1 (an unautomated, drylot system) but not for systems 2a and 2b.

Mixed systems allow animals access to pasture feed sources in addition to certain concentrates, minerals and dry roughages. System 3 was the easiest to specify since it was the most popular among the producers surveyed. System 3 is nonautomated and requires no special facilities, only available pasture land. It is segmented into four time periods, because available feed sources vary substantially with the season of the year. Systems 4a and 4b are quite similar. Each of these systems is segmented into two 120-day periods. In the initial 120-day period, system 4a utilizes hay and grain, but no silage; system 4b utilizes silage, grain, but no hay. During the second 120-day period (starting April 1st) both systems rely heavily on pastures with some protein supplements and mineral sources, available as needed. Note that animals gain more total pounds in mixed systems compared with other types.

All three *pasture* systems (5, 6 and 7) are primarily grazing systems but with protein supplements and minerals available if needed. Systems 5 and 6 are summer grazing systems. System 5 uses heifers, whereas system 6 uses steers. Animals for system 7 utilize only pasture with supplemental hay during the winter months. This combination of only pasture feed activities and low weight gains over a year's duration leads some producers to call this "roughing the animals through." Note the lower average daily gain for this system--8 pounds as compared with 1.1 pounds for system 6.

Determining Least Cost Feeds: Procedures

Conventional Linear programming (LP) was used to estimate the least cost feed mix and the total cost of each mix for each feed system identified as feasible. The model for each system may be expressed as:

$$\text{Minimize} \sum_{j=1}^{M} C_j X_j$$

$$\text{Subject to} \sum_{j=1}^{n} A_{ij} X_j \geq B_i \text{ for } i = 1, 2, \ldots, n$$

$$\text{and } X_j \geq 0 \text{ for all } j.$$

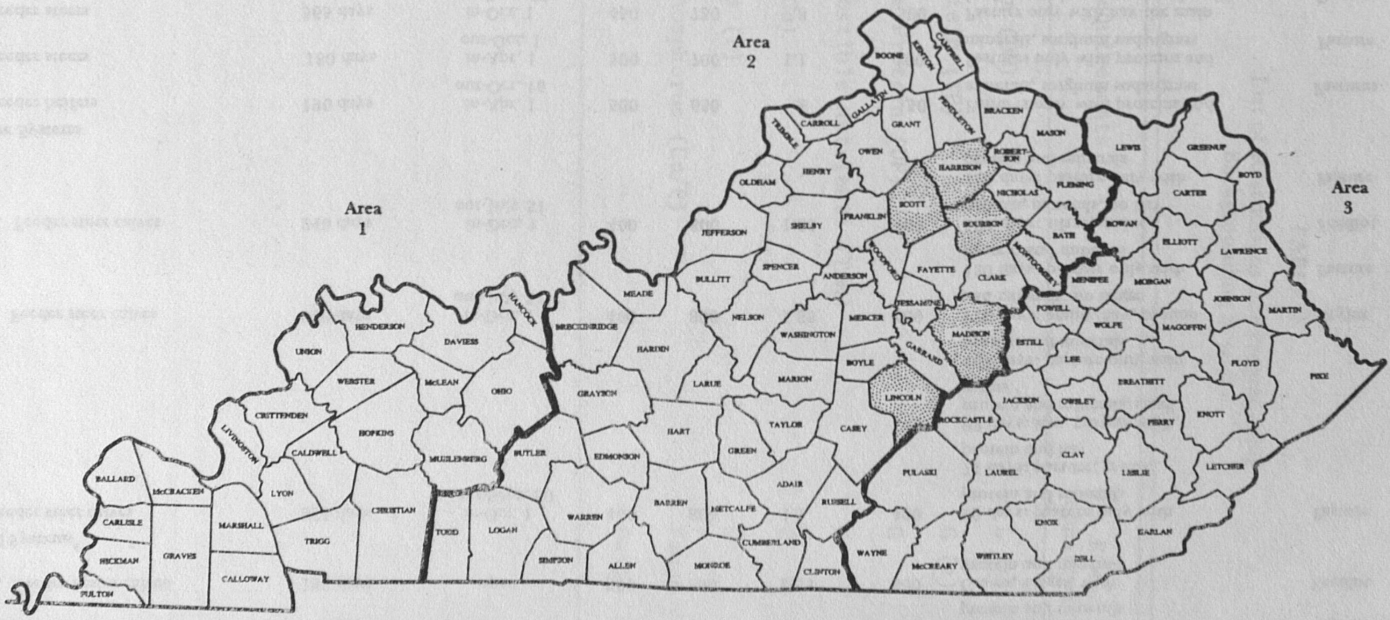

Figure 1.–Kentucky Substate Areas for Beef Cattle Production

TABLE 1

Typical Backgrounding Feed Systems Identified as Feasible

System Number, Description	Phase	Date	Weight In	Weight Out	Gain Daily (ADG)	Gain Total	Feed Activities[a] Considered	Facility
Nonpasture Systems								
1. Feeder steer calves	212 days	in-Oct. 1 out-May 1	400	750	1.65	350	Grains, silages, hay with protein and minerals	Drylot
2. A. Feeder steer calves	182 days	open[b]	500	800	1.65	300	Grains, silages, with protein and minerals	Feedlot
B. Feeder heifer calves	182 days	open	500	800	1.65	300	Grains, silages, with protein and minerals	Feedlot
Mixed Systems[c]								
3. Feeder steer calves	365 days	in-Oct. 1 out-Sept. 30	400	800	1.1	400	92 days: pasture only with protein and minerals	Pasture
							74 days: pasture, grains, protein and hay	
							92 days: hay, pasture with protein and minerals, small grains	
							107 days: pasture only with protein and minerals	
4. A. Feeder steer calves	240 days	in-Dec. 1 out-July 31	400	800	1.65	400	120 days: grains, hay, protein and minerals, no silage	Drylot
							120 days: pasture only with protein and minerals	Pasture
B. Feeder steer calves	240 days	in-Dec. 1 out-July 31	400	800	1.65	400	120 days: silage, grains, protein, minerals, no hay	Feedlot
							120 days: pasture only with protein and minerals	Pasture
Pasture Systems								
5. Feeder heifers	190 days	in-Apr. 1 out-Oct. 16	500	650	.8	150	Pastures only with proteins and minerals, sorghum sudangrass	Pastures
6. Feeder steers	180 days	in-Apr. 1 out-Oct. 1	500	700	1.1	200	Pastures only with proteins and minerals, sorghum sudangrass	Pasture
7. Feeder steers	365 days	in-Oct. 1 out-Sept. 30	450	750	.8	300	Pasture only with hay the main feed source in winter months with minerals and protein	Pasture

[a] Feed activities considered are dictated by the system. Protein and minerals are included in all systems that are programmed.

[b] System 2a and 2b under nonpasture systems may be placed in the program any time during the year.

[c] Mixed systems include pasture activities in combination with grains, hay, silage, proteins and minerals.

TABLE 2

List of Restrictions For Programming Backgrounding Systems

Nutritional requirements (B_i)	Row constraint
1. Dry Matter (DM)	L (≤)
2. Total Protein (TP)	G (≥)
3. Digestible Protein (DP)	G
4. Total Digestible Nutrients (TDN)	G
5. Calcium (Ca)	G
6. Phosphorus (P)	G
7. Calcium/Phosphorus (Ca/P)	Range
8. Urea (u)	Range

where

- X_j denotes amount of each feed which will achieve some given daily gain by each beef animal (e.g., X_1 = pounds of protein supplement and X_2 = pounds of corn),
- C_j denotes the cost per unit (pounds, cwt.) of the jth feed,
- B_i denotes the nutritional requirement: the amount of total digestible nutrients, digestible protein, etc., for a specified total weight gain by each beef animal for a certain period, and
- A_{ij} denotes the estimated amount of each nutrient for each nutritional requirement (i) supplied by each feed (j), expressed in percentages.

Mechanically, this model was fitted using the IBM MPS-360 algorithm for each feeding system using data on: (1) nutritional requirements of the beef animals for a given average daily gain, (2) nutrients supplied by each feed source, (3) prices of feed sources.

Nutritional Requirements

Nutritional requirements, the right hand side (RHS or B_i), are listed in Table 2. Each of these requirements was calculated for the beef animal in a given backgrounding system using standards listed in *Nutrient Requirements of Beef Cattle*, 1970, pp. 22-25. The first six requirements were expressed in total number of pounds required for the beef animal to gain the total specified number of pounds, on an *as-fed basis*. A weighted average of average daily feed needs was calculated, given a stipulated average daily gain. Having determined the phase (number of days) for each system, nutritional requirements for the total weight gain (e.g., 400 pounds) were determined based upon the average daily needs.

Three average daily weight gains (ADG's) were selected, i.e., .8, 1.1 and 1.65 pounds, to span the range of average daily gains normally expected for background feeding. Specific backgrounding systems including the total number of feeding days, dictate the average daily gain (ADG). Backgrounding operations usually are not geared for high levels of performance such as 2 pounds per day and over. Feedlot operators usually prefer yearlings in thin to medium flesh; 2 pounds per day on calves of average genetic ability tends to make them fat (Gay, 1973, p. 3). Only with calves of superior genetic ability can growth gains of 2 pounds per day be realized. In contrast, lightweight calves (300-500 pounds) do not have the capacity to consume enough energy to gain in excess of 1 pound per day, especially if being fed only hay. Gay notes that, if a backgrounding operation consists of wintering and grazing phases, gains in excess of 1.5 pounds per day during the winter will reduce the summer gains.

Nutrient requirements, the B_i of Table 2, identify rows in the A_{ij} matrix. Supplying the needed nutritional requirements balances the feed intake for the beef animals. To maintain the proper Ca/P ratio, "tuning-up" programming procedures were employed. It was determined, for example, that calcium intake cannot be more than twice as great as phosphorus intake--otherwise the average daily gain is lowered. A ratio of 1.3 is preferred, but a 2 to 1 ratio is still acceptable. The range section of the MPS-360 LP model was used to specify this constraint (Batterham and Hill, p. 9).

Certain feeds in excessive amounts may be toxic to younger beef animals. Such an example is urea (B_8). Animal nutritionists at the University of Kentucky point out that not more than one-third of the total protein requirement should be supplied by urea (nonprotein nitrogen). Hence, a range row constraint was used to restrict urea to safe quantities.

Feed Selection and Nutrients Furnished

Each column in the A_{ij} matrix is a feed source (activity), one of numerous possible feed sources considered available to supply the necessary nutritional requirements. Feed activities chosen for consideration fell under the large headings of concentrates (which consists of grains, processed feeds, and proteins), silages, mineral sources, dry roughages, and green forages or pastures. Selection of these feed activities was based upon a list of feeds commonly used in beef cattle rations (*Nutrient Requirements of Beef Cattle*, 1970, pp. 28-47) and the researchers' knowledge of Kentucky feed sources, potentials, and commonly used feed activities by Kentucky beef cattle producers (see Appendix Table 1).

Not every feed source listed in this table was considered as a potential feed activity for each backgrounding system identified as feasible. Depending upon the characteristics of the system being considered, certain activity categories (e.g., hays or silages) were deleted from a given system before it was programmed. Other feed activities were deleted from backgrounding systems as they were programmed either because they could not be produced locally, were not commonly used, or were not generally available for sale in the feeding area.

Feed composition data were obtained from the *Atlas of Nutritional Data on United States and Canadian Feeds* (1971). Each feed source in this publication had an index number. This number identified the feed source as a sole activity which carries an "NRC name." Each "NRC name" consists of eight components and provides a qualitative feed description. The components are:

(1) Origin or parent material,
(2) Species, variety, or kind,
(3) Part eaten,
(4) Process(es) and treatment(s) to which the parent material or the part eaten had been subjected,
(5) Stage of maturity (applicable only to forages),
(6) Cutting or crop (applicable only to forages),
(7) Grade and quality designations, and
(8) Classification.

After locating the "NRC name," data on dry matter, total protein, digestible protein, total digestible nutrients, calcium, and phosphorus were obtained for each feed source on an *as-fed basis*.

Of the pasture activities selected, only about one-half could be found in the *Atlas of Nutritional Data on U.S. and Canadian Feeds* (1971) in the combination and stage of maturity in which the authors found them to be necessary. However, each type of pasture used was available in the NRC publication on an individual basis, if not in the mixed-form. Animal Science and Agronomy forage experts at the University of Kentucky provided additional information on mixed-form data.[1] Available data on pasture feed composition indicated little difference in feed composition of most forage plants as to stage of maturity, variety, and species. Accordingly, two assumptions were made for unavailable pasture data:

(1) Mixed pastures (one grass and one legume) always consist of 50-50 mixtures and will remain so for the specified life of that pasture,

(2) Mixed pasture feed composition will comprise 50% of the nutrient composition from each pasture type in the mixture (added together), and this is not significantly different from the real world situation.

Accordingly, pasture feed composition data were "synthesized" for those pastures for which exact data were not available.

Feed Prices

Feed prices are quite unstable over time, even during time periods that economists consider fairly normal. During 1972–1974, for example, livestock producers observed how quickly upward shifts in feedstuff prices can take place (see *Feedstuffs*, 1974). Increased demand,

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1 **Interviews were conducted with Dr. James Boling, Animal Scientist; and Mr. J. K. Evans and Dr. W. C. Templeton, Agronomy Forage Specialists.**

domestic and international, for grains and protein sources, coupled with very poor weather conditions during each growing season, have been major factors contributing to rising feed prices. Thus, no single level of prices is adequate to represent the feed market price situation. Initially, three price levels were identified. However, the P_1 or lowest price level was eventually dropped because feed price levels increased beyond that level during the study period.

All systems were first programmed at a more-or-less model price level, identified as P_2. During the summer of 1974, we studied feed prices for grains, proteins, and processed feeds over the past five years from several information sources, including the 1974 *Feedstuffs* magazines and the Statistical Reporting Service (SRS) in Louisville, Kentucky. Statistical Reporting Service (SRS) data were quite useful, providing Kentucky feed prices for most all feed sources considered. To establish uniformity, all feed prices were converted to prices per 100 pounds. No real time could be established, so current (1974) prices were used for the base or P_2 price level.

Feed prices for silages are difficult to establish since there is no active silage market. Certain rules-of-thumb for valuation are available (see Allen and Browning, 1974). However, we decided to modify their suggested silage prices because these prices did not entirely reflect feedstuff supply and demand situations for 1974 (see *Feedstuffs*, 1974). The P_2 price data used for silages may be slightly below current levels, but this can be corrected by parametric programming.

Dry roughage or hay prices are easier to derive. The Statistical Reporting Service (SRS) has price information on most of the hays in Kentucky. Also, when the Central Kentucky backgrounding farmer survey was conducted, market prices for certain grains and hays were obtained.

Green forage and pasture values are extremely difficult to establish. Many researchers have pondered the question of what an acre of pasture is worth. There are almost as many approaches to answering this question as there are forage economists. For this study, several approaches were considered including rental rates, value in hay equivalents, and production costs. The production cost approach is fully described, along with pasture enterprise budget results, in a companion publication (Rutledge et al., 1975).

Least Cost Feed Mixes: Programmed Results

Contrary to conventional belief, pasture systems did not result in lowest feed costs per pound of gain. Comparisons of feed cost efficiency among systems were made by calculating minimum feed cost per 100 pounds of gain (Table 3).

Comparisons show that a mixed system, 4a, is the most feed cost efficient.[2] System 4a was previously identified (Table 1) as a 240-day combination drylot and summer grazing system with a 1.65 pound average daily gain. System 4b costs only $0.73 more per 100 pounds gain. Recall that these are identical systems except for equipment and feed activities utilized. Ranking third and fourth in feed cost efficiency were a nonpasture system (1) and a pasture system (6). The remaining rank of systems according to feed cost efficiency is 3, 7, 2a, 5 and 2b.

As a group, mixed backgrounding systems were found to be the most feed cost efficient. Minimum feed costs per 100 pounds of gain were calculated on a group average to be:

Type of system	Dollars per cwt.
Nonpasture	$17.50
Mixed	14.03
Pasture	16.94

Nonpasture Systems

Table 4 summarizes programming results, i.e., optimal feed combinations,

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2 That is, the programmed value of the objective function divided by the total pounds of weight gained (total feed cost per 100 pounds gain) is the lowest of systems being compared.

TABLE 3

Comparative Feed Costs Per Hundred Pounds Gain: Non-Pasture, Mixed, and Pasture Systems

System[a]	Average daily gain (ADG) (pounds)	Phase	(days)	Minimum feed cost per 100 pounds gain (dollars)
Non-pasture Systems				
1.	1.65	Oct. 1 - May 1	212	14.26
2a.	1.65		182	18.50
2b.	1.65		182	19.75
Mixed Systems				
3.	1.10	Oct. 1 - Sept. 30	365	15.27
4a.	1.65	Dec. 1 - July 31	240	13.04
4b.	1.65	Dec. 1 - July 31	240	13.77
Pasture Systems				
5.	.80	April 1 - Oct. 16	190	18.82
6.	1.10	April 1 - Oct. 1	180	14.39
7.	.80	Oct. 1 - Sept. 30	364	17.62

[a]See Table 1 for a complete description of each system.

for the three nonpasture systems. For example, for system 1 the least cost feeding program consists of 3,081.9 pounds of corn silage, 14.9 pounds of deflourinated rock phosphate, 493.1 pounds of grass hay, 457.6 pounds of tall fescue hay, and 1,010.7 pounds of fescue-ladino clover hay. This is the total pounds of each feed, on an *as-fed basis*, for the entire 212-day feeding period. No analyses were made for shorter run segments of this period, e.g., the month of January versus the month of April. The cost of this feed is shown to be $49.92 in order to allow each steer calf to gain a total of 350 pounds, i.e., $14.26 per cwt. gain.

For system 1, given the feed prices listed in Appendix Table 1, several hay activities came close to entering the optimal solution. Red clover hay or bluegrass hay would have increased the total cost per period only very slightly.

Systems 2a and 2b are fully automated feedlot systems. Therefore, hay activities were not considered as program activities. (See Appendix Table 2 for feed activities which are eligible to enter any optimal solution.) When hay activities were restricted from consideration, concentrates entered the programming results and forced the minimum feed cost solution much higher.

Mixed Systems

Table 5 provides a summary of optimal feed combinations, feed input quantities, and minimum objective function values for mixed backgrounding systems using P_2 feed price levels.

System 3 was the most popular system in the entire backgrounding survey. Programming this system posed certain problems because the time period spanned one full year and all feed activities are not available in every season. Linear programming techniques do not easily permit a single programming of the entire system. To avoid many special constraint rows, the year was partitioned into four specially constructed time periods of 92, 74, 92, and 107 days. Each time period was separately programmed. This procedure allowed the solution to contain different sets of alternative feed activities in the respective time periods which make the system's operation practical. For example, low-cost pasture activities cannot supply all the nutritional requirements for a winter feeding period. Thus, pasture activities either were deleted or upward bounded by an estimated quantity.

System 3 began with a fall grazing period, with fresh fescue pasture providing the bulk of the forage source. Because fescue pasture is available only in small amounts, an upper bound of 344.9 pounds was stipulated for the winter feeding period. This restriction provided that no more than 10 percent of the dry matter requirement for the animal during these months could be supplied by pasture activities. During the spring period grass hay was fed for 28 days in the amount of 430 pounds until forage carrying capacity was large enough to allow this restriction to be dropped. Winter wheat was fed for 30 days to lower feed costs until forage had gained adequate growth. Fescue, orchardgrass and alfalfa-orchardgrass provided summer grazing.

Both systems 4a and 4b are 240-day combination, confinement and grazing systems. Silages are not considered as alternative feed activities in the initial 120-day drylot period for system 4a. System 4b considers silages but not hays. Both systems contained identical optimal solutions for the grazing phase.

Mixed backgrounding systems each produce 400 pounds of total gain. With the highest total feed cost of $61.07, system 3 proved to be the most feed cost inefficient of the three mixed systems. The system's inflexibility was a factor in the higher cost.

Pasture Systems

Table 6 presents a summary of optimal feed combinations, feed input quantities, and minimum feed cost values for pasture systems using P_2 feed price levels. Systems 5 and 6 are spring-summer grazing systems; system 5 uses heifers, whereas, system 6 uses steers. Midbloom orchardgrass, early bloom fescue, and midbloom alfalfa-orchardgrass entered the optimal solution for both systems. Fescue

TABLE 4

Non-Pasture Systems: Optimal Feed Combinations

System (ADG)	Period or phase	Feed activities entering optimal solution	Pounds per period	Price per 100 pounds (P_2 level)	Minimum feed cost: Per Period	Minimum feed cost: Per 100 pounds of gain
					(dollars)	
1. (1.65)	Oct. 1 - May 1	Corn silage, X_{19}	3081.9	.70	49.92	14.26
		Deflourinated rock phosphate, X_{30}	14.9	8.75		
		Grass hay (all analysis), X_{54}	493.1	1.25		
		Tall fescue hay, X_{57}	457.6	1.25		
		Fescue-Ladino clover hay, X_{58}	1010.7	1.50		
2a. (1.65)	182 days	Corn gluten meal, X_5	223.8	5.90	55.49	18.50
		Urea, X_{17}	6.3	9.00		
		Corn silage, X_{19}	5942.8	.70		
		Dicalcium phosphate, X_{29}	.3	14.00		
		Deflourinated rock phosphate, X_{30}	1.1	8.75		
2b. (1.65)	182 days	Corn gluten meal, X_5	224.9	5.90	59.24	19.75
		Urea, X_{17}	3.2	9.00		
		Corn silage, X_{19}	5748.2	.70		
		Grain sorghum silage, X_{20}	1090.6	.50		

TABLE 5

Mixed Systems: Optimal Feed Combinations

System (ADG)	Period or phase (days)	Feed activities entering optimal solution	Pounds per period	Minimum feed cost: P_2 price per 100 pounds	Minimum feed cost: Per period	Minimum feed cost: Per 100 pounds of gain
					(dollars)	
3. (1.1)	Oct. 1 - Dec. 31 (92)	Fescue pasture (fresh), X_{73}	3271.8	.33	12.39	15.27
		Alfalfa-Orchardgrass pasture (fresh), X_{82}	638.7	.25		
	Jan. 1 - Mar. 15[a] (74)	Fescue pasture - (fresh), X_{73}	344.9	.33	14.00	
		Grass hay, X_{54}	678.2	1.25		
		Fescue hay, X_{57}	165.2	1.25		
		Fescue-Ladino Clover hay, X_{58}	154.6	1.50		
	Mar. 16 - June 15[b] (92)	Grass hay, X_{54}	430.0	1.25	17.73	
		Fescue pasture - (fresh), X_{73}	974.2	.33		
		Wheat (small grain for pasture), X76	1632.1	.56		
	June 16 - Sept. 30 (107)	Fescue pasture - (early-bloom), X_{73}	1677.9	.33	16.95	
		Alfalfa-Orchardgrass pasture (mid-bloom), X_{82}	260.2	.25		
		Orchardgrass pasture - (mid-bloom), X_{75}	2690.9	.40		
4a. (1.65)	Dec. 1 - Mar. 31 (120)	Barley, X_7	46.5	3.33	30.73	13.04
		Deflourinated rock phosphate, X_{30}	23.1	8.75		
		Fescue-Ladino Clover hay, X_{58}	1810.8	1.50		
	Apr. - July 31 (120)	Fescue pasture - (early-bloom), X_{73}	2611.1	.33	21.44	
		Orchardgrass pasture - (mid-bloom), X_{75}	3081.4	.40		
		Alfalfa-Orchardgrass pasture (mid-bloom), X_{82}	200.7	.25		

(Continued)

TABLE 5--continued

System (ADG)	Period or phase (days)	Feed activities entering optimal solution	Pounds per period	Minimum feed cost: P_2 price per 100 pounds	Minimum feed cost: per period	Minimum feed cost: Per 100 pounds of gain
				(dollars)		
4b. (1.65)	Dec. 1 - Mar. 31 (120)	Corn gluten meal, X_5	131.2	5.90	33.65	13.77
		Urea, X_{17}	3.8	9.00		
		Corn silage, X_{19}	3624.0	.70		
		Dicalcium phosphate, X_{29}		14.00		
		Deflourinated rock phosphate, X_{30}	1.6	8.75		
	Apr. 1 - July 31 (120)	Fescue pasture - (early-bloom), X_{73}	2611.1	.33	21.44	
		Orchardgrass pasture (mid-bloom), X_{75}	3081.4	.40		
		Alfalfa-orchardgrass pasture (mid-bloom), X_{82}	300.7	.25		

[a]Even though the identification of the system dictated pasture availability to the backgrounding animals, the winter feeding phase was restricted to no more than 10% of the dry matter requirement for the animal during those months that could be supplied by pasture activities, since they simply were not available in large enough amounts to meet the animals' nutritional needs.

[b]The spring phase of system 3 required the necessary feeding of hay until forage carrying capacity was large enough. Since many Kentucky farmers utilize small grain for grazing in early spring in such a system as 3, winter wheat was forced in at a lower feed cost instead of using only hay until forage had gained adequate growth.

is utilized in early spring and late fall after frost because its nutritional value is at the peak during the summer months. Alfalfa-Kentucky bluegrass and fescue-red clover came close to entering the optimal program.

Pasture system 7 is not a very commonly used system. Spanning a full year, the programming procedures used are very similar to those in system 3. All pasture activities, in reality, are not available in the same quantity or stage of maturity each and every season. Time periods of 61, 121, 61 and 122 days were separately programmed. These periods were selected to make adequate pasture and hay activities available in the respective time periods. Approximate dates indicate that time periods of system 7 tend to follow forage growth stages and maturity. For example, during the winter, pasture availability is low but in large enough quantities to provide some nutritive value. Fresh fescue and fresh fescue-red clover pasture accordingly were upper bounded at 519.27 pounds and 589.17 pounds, respectively. These restrictions provide that no more than 20 percent of the dry matter requirement for the animal during these months could be supplied by such pasture activities. Hay activities provided the remaining nutritional needs.

The heifer system (5) again proved to be the most feed cost inefficient. System 7 was less feed cost efficient than system 6 owing partially because of its rigid structure.

Varying Feed Prices: Programmed Results

Recall that grains, proteins, and processed feeds rarely entered the optimal solutions at the P_2 price level. This could be due to the prices (relative) which were entered in the objective function being too high. Therefore, the prices of all hay and silage activities were increased by 40 percent and 50 percent, respectively, defined as the P_3 price level (see Appendix Table 1). Systems were programmed exactly as they were at the P_2 level using the same feed sources and the same restrictions.

Pasture systems were not programmed at these higher prices, since only hay and silage prices were altered. Unless pasture prices are altered in different proportions, the activities entering the optimal solution or their amounts will not be changed from the basic programming results (Table 6).

All three nonpasture systems were programmed using two parametric pricing schemes (i.e., two P_3-level schemes). Table 7 shows results from the two schemes for system 1, essentially involving increasing silage and hay prices. Programming results for system 1 at the basic (P_2) price level are also listed for easy comparison. Pricing scheme A maintained concentrates and silages in the program at P_2 price levels, but hay activities were changed to P_3 prices, 40 percent higher than P_2 levels. The effects of increasing hay prices are easily detected. Instead of three hay activities, as in the P_2 minimum feed cost solution, fescue-ladino clover hay entered as the sole hay activity. Also, corn silage significantly increased in amount after the price changes.

Pricing scheme B maintained concentrates in the linear programming (LP) program at P_2 prices. Silages, hays, and urea were increased to P_3 prices--hay being 40 percent higher, with silages and urea 50 percent higher. Note, for example, that this reduces corn silage usage only 160 pounds compared with P_2 results. Hay activities were similar for both solutions. Grains, proteins, and processed feeds still failed to enter the optimal solution. Barley and grain sorghum, however, came much closer to entering the optimal solution.

Only selected time period segments of the three mixed systems were programmed using P_3 prices, because grazing periods did not involve pasture price increases. Fall and summer grazing periods for system 3 were not programmed at P_3 prices.

Table 8 shows parametric programming results for selected feeding periods using a simple parametric pricing scheme for systems 4a and 4b. Results from the P_2 level are also presented for comparison purposes.

The 4a system pricing scheme entered hays at P_3 prices while holding concentrates at P_2 prices. Note that barley entered the

TABLE 6

Pasture Systems: Optimal Feed Combinations

System (ADG)	Period or phase (days)	Feed activities entering optimal solution	Pounds per period	P_2 price per 100 pounds	Minimum feed cost: Per period	Minimum feed cost: Per 100 pounds of gain
					(dollars)	
5. (.8)	Apr. 1 - Oct. 16 (190)	Fescue pasture - (early-bloom), X_{73}	2108.2	.33	28.23	18.82
		Orchardgrass pasture - (mid-bloom), X_{75}	4850.8	.40		
		Alfalfa-orchardgrass pasture (mid-bloom), X_{82}	749.6	.25		
6. (1.1)	Apr. 1 - Oct. 1 (180)	Fescue pasture - (early-bloom), X_{73}	3145.6	.33	28.78	14.39
		Orchardgrass pasture - (mid-bloom), X_{75}	4461.9	.40		
		Alfalfa-orchardgrass pasture (mid-bloom), X_{82}	221.5	.25		
7. (.8)	Oct. 1 - Nov. 30 (61)	Tall fescue pasture - (fresh), X_{73}	1928.2	.33	7.44	17.62
		Alfalfa-orchardgrass - (fresh), X_{82}	433.7	.25		
	Dec. 1 - Mar. 31 (121)	Grass hay, X_{54}	668.9	1.25	20.43	
		Fescue, fescue-ladino clover hay, $X_{57,58}$	651.8	1.25-1.50		
		Fescue pasture - (fresh), [a]X_{73}	519.3	.33		
		Fescue-red clover pasture, [a]X_{81}	589.2	.37		
	Apr. 1 - May 31 (61)	Fescue pasture - (fresh), X_{73}	1928.2	.33	7.44	
		Alfalfa-orchardgrass - (fresh), X_{82}	433.7	.25		
	June 1 - Sept. 30 (122)	Fescue pasture - (early-bloom), X_{73}	1301.	.33	17.55	
		Alfalfa-orchardgrass pasture (mid-bloom), X_{82}	3034.1	.25		
		Orchardgrass pasture (mid-bloom), X_{75}	451.5	.40		

[a]Even though the identification of the system dictated pasture availability to the backgrounding animals, the winter feeding phase was restricted to no more than 10% of the dry matter requirement for the animal during those months could be supplied by pasture activities since they were not available in large enough amounts to meet the animals' nutritional needs.

TABLE 7

Optimal Feed Combinations for System 1 Using A Simple Parametric Pricing Scheme[a]

Pricing scheme[b]	Feed activities entering optimal solution	Results after price changes[b]			Results at P_2 prices		
		Pounds per period	Feed Cost per period	Feed cost per 100 lbs. gain	Pounds per period	Feed cost per period	Feed cost per 100 lbs. gain
			-----(dollars)-----			-----(dollars)-----	
A.	Corn Silage, X_{19}	4589.0	58.68	16.76	3081.9	49.92	14.26
	Urea, X_{17}	1.8			0		
	Dical. Phosphate, X_{29}	13.7			0		
	Deflour. Rock Phosphate, X_{30}	3.8			14.9		
	Grass hay, X_{54}	0			493.1		
	Tall Fescue Hay, X_{57}	0			457.1		
	Fescue-Ladino Clover Hay, X_{58}	1145.1			1010.7		
B.	Corn Silage, X_{19}	2922.0	71.41	20.40			
	Deflour. Rock Phosphate, X_{30}	15.1					
	Fescue Hay, X_{57}	1048.7					
	Fescue-Ladino Clover Hay, X_{58}	1002.7					

[a]Period: October 1 - May 1. ADG equals 1.65 lbs.

[b]Pricing Scheme A: Concentrates and silages at P_2 prices; hay prices increased 40%
Pricing Scheme B: Concentrates at P_2 prices; silage prices increased 50%; hay prices increased 40%.

TABLE 8

Systems 4a and 4b: Optimal Feed Combinations Using A Simple Parametric Pricing Scheme[a]

System	Feed activities entering optimal solution	Results after price changes: Pounds per period	Results after price changes: Feed cost per period	Results after price changes: Feed cost per lbs. gain	Results at P_2 prices: Pounds per period	Results at P_2 prices: Feed cost per period	Results at P_2 prices: Feed cost per lbs. gain
			-----(dollars)-----			-----(dollars)-----	
4a.	Barley, X_7	413.2	41.10	15.64	46.5	30.73	13.04
	Deflour, Rock Phosphate, X_{30}	2.9			23.1		
	Grass Hay, X_{54}	672.9			0		
	Fescue Hay, X_{57}	576.1			0		
	Fescue-Ladino Clover Hay, X_{58}	249.3			1810.8		
4b.	Corn Gluten Meal, X_5	129.3	46.61	17.00	131.2	33.65	13.77
	Barley, X_7	17.2			0		
	Urea, X_{17}	3.9			3.8		
	Corn Silage, X_{19}	3583.8			3624.0		
	Dical, Phosphate, X_{29}	0			.5		
	Deflour, Rock Phosphate, X_{30}	2.1			1.6		

[a]Programming results are for the initial 120-day feeding period. The grazing period was not programmed, since pasture values were not changed.

[b]System 4a: Concentrates at P_2 prices; hay prices increased 40%.
System 4b: Concentrates at P_2 prices; silage prices increased 50% and hay prices increased 40%.

TABLE 9

Comparative Feed Costs Per Hundred Pounds Gain: Non-Pasture and Mixed Systems Programmed at the P_3 Price Level With Pasture Systems At The P_2 Level

System	Programmed price level	Period (days)	System minimum feed cost per 100 lbs. gain[a]
Non-Pasture systems			
1[b]	P_3	Oct. 1 - May 1 (212)	$20.40
2a	P_3	182 days	25.55
2b	P_3	182 days	27.42
Mixed systems			
3	P_2	Oct. 1 - Dec. 31 (92)	17.09
	P_3	Jan. 1 - Mar. 15 (74)	
	P_3	Mar. 16 - June 15 (92)	
	P_2	June 16 - Sept. 30 (107)	
4a	P_3	Dec. 1 - Mar. 31 (120)	15.64
	P_2	April 1 - July 31 (120)	
4b	P_3	Dec. 1 - Mar. 31 (120)	17.00
	P_2	April 1 - July 31 (120)	
Pasture systems[c]			
5	P_2	April 1 - Oct. 16 (190)	18.82
6	P_2	April 1 - Oct. 1 (180)	14.39
7	P_2	Oct. 1 - Sept. 30 (365)	17.62

[a]P_3 efficiency measures were identified as such for any system which had a portion (or the entire system) programmed using P_3 prices.

[b]Although two programs were run using P_3 prices for system 1, the program results where only concentrates were held to P_2 prices is most characteristic of the parametric pricing scheme.

[c]Same results for pasture systems are shown in Table 6, because no prices are changed.

optimal solution in a much larger quantity. Grass and fescue hays were new additions. Red clover hay would not be an expensive substitute.

After increasing silage prices by 50 percent, barley was the sole addition to the optimal solution for system 4b. With the higher corn silage price, barley could provide the nutrients cheaper as corn gluten meal entered in a lower quantity than in the P_2 programming solution.

Of the rise systems being compared, system 4a was the most feed cost efficient, even for the P_3 price levels. In contrast, system 3 is still the least feed cost efficient of the mixed backgrounding systems. Hay prices were increased 40 percent for system 3. Winter wheat, grass hay, and fescue pasture were the feed sources utilized in the spring feeding period. Feed activities and input quantities for the winter feeding period were identical to · those obtained in the P_2 programming results. System 3's total minimum feed cost was raised to $17.09 per 100 pounds gain even after increasing hay prices (Table 9).

As expected pasture systems improved their relative positions in feed cost efficiency from the P_2 programming results. Table 9 presents the comparative feed costs per 100 pounds of gain for the systems programmed at the P_3 price level compared to the pasture systems. System 6 has the best feed cost efficiency--$14.39 per 100 pounds gain. In general, however, mixed backgrounding systems are still the most feed cost efficient, even after price increases.

Conclusions

Analysis of the basic programming results reveals that grains, protein supplements, and processed feeds rarely enter optimal solutions. Moreover, even after silage and hay prices are sharply increased, concentrates still fail to enter the optimal solutions in significant quantities. Certain conclusions may be drawn from such results:

(1) Concentrates are priced very high relative to their nutritional values as compared with other feed sources available for backgrounding beef cattle. This implies two things. First, backgrounders definitely cannot afford to use grains, proteins, and processed feeds alone from the standpoint of feed cost efficiency. Second, hay and silage are the principal feed sources for use in various backgrounding systems.

(2) Basic design and characteristics of mixed backgrounding systems contribute to lower feed cost because of:

- (1) Flexibility in Scope--Backgrounding systems using only pastures and other forages are not as adaptable. When limited in scope, available feed activities are reduced. By reducing the set of alternatives from which feed sources may be selected, total feed costs are forced higher.
- (2) Timing--Making feed activities available at the proper time is important and requires careful management. Additional feed must be made available when forage production is low in winter months. Feed cost efficiency is reduced with such a system.
- (3) Animal Selection--From the results in this study, heifers required more feed to meet their higher, nutritional requirements. Heifer systems proved to be the most feed cost inefficient.

Generally, these characteristics are found in mixed backgrounding systems. Utilizing concentrates alone or pastures alone is not the most feed cost efficient. However, this study has considered only feed cost efficiency. In general, all farm resources dictate, to varying degrees, the manner in which farm enterprises are organized. In selecting any one system, many other factors in addition to feed costs need to be considered: Profit margins, land resources, feed supply, relative cost of equipment and facilities, feed cost efficiency, and others.

APPENDIX TABLE 1

Feed Prices Listed By Common Units

Feed Activities	Unit	P_2 Price[a] Level	P_3 Price[b] Level
Concentrates		(dollars)	
(X_1) Corn; #2 54#/bu.	bushel	3.00	
(X_3) Corn distillers dried grains	ton	130.00	
(X_4) Corn distillers solubles	ton	135.00	
(X_5) Corn gluten meal	100 lb	5.90	
(X_6) Ground ear corn	100 lb	5.61	
(X_7) Barley	bushel	1.60	
(X_8) Wheat	bushel	4.50	
(X_9) Oats	bushel	1.40	
(X_{10}) Grain sorghum	bushel	1.80	
(X_{11}) Milo sorghum	100 lb	5.30	
(X_{12}) Wheat middlings	100 lb	6.15	
(X_{13}) Alfalfa meal	100 lb	5.50	
(X_{14}) Cottonseed meal	ton	220.00	
(X_{15}) Soybean meal	ton	280.00	
(X_{16}) Linseed meal	ton	175.00	
(X_{17}) Urea - 45% N	ton	180.00	300.00
(X_{18}) Cane molasses	100 lb	5.40	
Silages			
(X_{19}) Corn silage, well-eared	ton	14.00	21.00
(X_{20}) Grain sorghum silage	ton	10.00	15.00
(X_{21}) Alfalfa silage	ton	15.00	22.40
(X_{22}) Red clover silage	ton	12.00	18.00
(X_{23}) Alfalfa silage MN 30% Max 60% dry matter	ton	20.00	30.00
(X_{25}) Wheat silage	ton	12.00	18.00

Continued

APPENDIX TABLE 1--Continued

Feed Activities	Unit	P_2 Price[a] Level	P_3 Price[b] Level
Mineral Sources		(dollars)	
(X_{29}) Dicalcium phosphate	ton	280.00	
(X_{30}) Deflourinated rock phosphate	ton	175.00	
(X_{32}) Steamed bone meal	ton	290.00	
Dry Roughages (Hay)			
(X_{34}) Alfalfa (immature)	ton	58.00	81.20
(X_{35}) Alfalfa (pre-bloom)	ton	54.00	75.60
(X_{36}) Alfalfa (early-bloom)	ton	54.00	75.60
(X_{37}) Alfalfa (mid-bloom)	ton	50.00	70.00
(X_{40}) Alfalfa - orchardgrass	ton	49.00	68.60
(X_{41}) Alfalfa - Timothy, cut 1	ton	45.00	63.00
(X_{42}) Alfalfa - Timothy, cut 2	ton	50.00	70.00
(X_{43}) Red clover (pre-bloom)	ton	42.00	58.80
(X_{44}) Red clover (mid-bloom)	ton	35.00	49.00
(X_{45}) Red clover (full-bloom)	ton	35.00	49.00
(X_{46}) Red clover - orchardgrass	ton	33.00	46.20
(X_{47}) Bluegrass	ton	30.00	42.00
(X_{48}) Orchardgrass	ton	32.00	44.80
(X_{53}) Grass-Legume (60-40)	ton	34.00	47.60
(X_{54}) Grass (mixed)	ton	25.00	35.00
(X_{55}) Legume-grass (60-40)	ton	37.00	51.80
(X_{57}) Fescue	ton	25.00	35.00
(X_{58}) Fescue-Ladino clover	ton	30.00	42.00
(X_{59}) Fescue-grass	ton	25.00	35.00
(X_{61}) Lespedeza (pre-bloom)	ton	43.00	60.20
(X_{62}) Lespedeza (early-bloom)	ton	36.00	50.40
(X_{63}) Lespedeza (mid-bloom)	ton	36.00	50.40
(X_{64}) Lespedeza (full-bloom)	ton	34.00	47.60

Continued

APPENDIX TABLE 1--Continued

Feed Activities	Unit	P_2 Price Level[a]	P_3 Price Level[b]
Dry Roughages (Hay)		(dollars)	
(X_{66}) Timothy (early-bloom)	ton	32.00	44.80
(X_{67}) Timothy (mid-bloom)	ton	35.00	49.00
(X_{68}) Timothy (late-bloom)	ton	30.00	42.00
(X_{70}) Soybean	ton	32.00	44.80
(X_{72}) Sudan	ton	30.00	42.00
Pastures[c]			
(X_{73}) Tall fescue	acre	69.28	
(X_{74}) Kentucky Bluegrass	acre	74.07	
(X_{75}) Orchardgrass	acre	73.65	
(X_{76}) Winter wheat	acre	44.75	
(X_{77}) Rye	acre	52.50	
(X_{78}) Tall fescue-ladino clover	acre	73.87	
(X_{79}) Kentucky Bluegrass-Ladino Clover	acre	79.46	
(X_{80}) Alfalfa-Kentucky Bluegrass	acre	91.30	
(X_{81}) Fescue-red clover	acre	85.80	
(X_{82}) Alfalfa-orchardgrass	acre	90.17	
(X_{83}) Sorghum-sudangrass	acre	123.80	
(X_{84}) Red clover-orchardgrass	acre	77.40	
(X_{85}) Orchardgrass-Ladino clover	acre	74.27	

[a] P_2 prices are current prices for 1974.

[b] Hay prices were increased 40%; silage prices by 50%.

[c] Refer to pasture budgets in Appendix Table 5 for more information.

APPENDIX TABLE 2

Feed Activities Considered As Possible Solutions For Each Backgrounding System[a]

System	System with segments	Feed activities (X's) Concentrates	Silages	Minerals	Roughage	Pastures
1		1,3-18	19-23,25	29,30	34-37,40-49, 53-55,57-59, 61-63,68,70,72	
2a		1,3-18	19-23	29,30,32		
2b		1,3-18	19-23	29,30,32		
3	Oct. 1 - Dec. 31	13-17		29,30,32		73-75,78,80 81,82,84,85
	Jan. 1 - Mar. 15	1, 3-18		29,30,32	34-37,40-49, 53-55,57-59, 61-64,66-68,72	73
	Mar. 16 - June 15	13-17		29,30,32	54	73-82,84,85
	June 16 - Sept. 30	13-17		29,30,32		73-75,78-85
4a	Dec. 1 - Mar. 31	1,3-18		29,30,32	34-37,40-49, 53-55,57-59, 61-64,66-68	
	April 1 - July 31	13-17		29,30,32		73-75,78-82 84,85
4b.	Dec. 1 - Mar. 31	5,17	19	29,30,32		
	April 1 - July 31	13-17		29,30,32		73-75,78-82, 84,85
5		13-17		29,30,32		73-75,78-85

Continued

APPENDIX TABLE 2--Continued

System	System with segments	Feed activities (X's) Concentrates	Silages	Minerals	Roughage	Pastures
6		13-17		29,30,32		73-75,78-85
7	Oct. 1 - Nov. 30	13-17		29,30,32		73-75,78-82, 84,85
	Dec. 31 - Mar. 31	13-17		29,30,32	34-37,40,41, 43-46,48,49, 53-55,57,58	73,74,78,79, 81
	April 1 - May 31	13-17		29,30,32		73-75,78-82 84,85
	June 1 - Sept. 30	13-17		29,30,32		73-75,78-85

[a]Refer to Appendix Table 1 for names of feed sources.

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