Alfalfa Demand Estimates Using Feed-Mix Models for the Dairy, Horse, and Beef Industries

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ALFALFA DEMAND ESTIMATES USING FEED-MIX MODELS

FOR THE DAIRY, HORSE, AND BEEF INDUSTRIES

BY

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INTRODUCTION

Alfalfa production in the United States increased 15% from 1975 to 1984 (from 78,183 million tons to 90,017 million tons). In 1984 U.S. alfalfa production accounted for 60% of the total U.S. hay production (USDA Agricultural Statistics: 1984). Furthermore, interest in alfalfa as a cash crop has increased due to depressed farm income levels. Thus, examining alfalfa's value as a feed ingredient as well as its cash crop potential merits attention.

Alfalfa's utility is derived from its value as a feed source. Horse, dairy, and beef enterprises use alfalfa for its high crude protein (15-20%), energy content, and digestibility. Demand for high quality alfalfa generates substantial prices well above average quotes. The 1985 U.S. and Kentucky annual average price was $73.86 per ton and $101.67 per ton, respectively. A premium is paid by the horse industry for top quality alfalfa. Hay dealers in Lexington quoted prices of $215 per ton in 1982 (Evans).

With real net farm income decreasing since 1973 (USDA Agricultural Statistics: 1985) the potential for alfalfa as a cash crop should be examined. States which import alfalfa need to evaluate their market and assess their potential to become more self-sufficient. This could enhance state farm income and possibly provide a lower-priced input to livestock producers.

In essence, alfalfa deficit states (primarily the southeast) need to be cognizant of their state-wide alfalfa demand. However, limited information is available concerning alfalfa demand in individual states. This study examines this issue and some of its implications.

OBJECTIVE AND PROCEDURE

The primary focus of this research is to compute state-wide alfalfa demand estimates and examine alfalfa's cash crop potential in the southeast. First, demand was estimated for the horse, dairy, and beef sectors for every state. Total state-wide alfalfa demand was the sum of the individual horse, dairy, and beef demand estimates. After state-wide alfalfa demand was determined, a regional evaluation was made of alfalfa's cash crop potential in the southeast by aggregating state-wide demand estimates and comparing these to production levels for 1982.

BACKGROUND INFORMATION

The primary market for alfalfa is horses, dairy, and beef farms, with limited quantities used by sheep and zoo operations. Horse owners pay premiums for top quality alfalfa in order to obtain an attractive green, leafy source of protein, free of foreign material, mold, and dust. Transportation costs are not a factor for some horseowners, who desire alfalfa hay that meets these criteria. For example, sone Kentucky horse farms have purchased alfalfa from as far away as Washington.

Since dairymen usually purchase lower quality alfalfa they usually pay lower prices than horse owners. Dairymen are also willing to substitute other roughages and nutrients to achieve a balanced but lower-cost ration.

Finally, beef feeders usually pay the lowest price for below average quality alfalfa since their enterprises have less stringent nutrient demands. Often, they use less expensive forages produced on their own farms.

Quality and protein levels are positively related and impact price accordingly. Variables that affect or reflect quality are: time of cutting, processing method, color, storage, foreign matter, and odor. Price differentials of forty dollars or more per ton are not uncommon, which indicates the heterogeneous nature of alfalfa. Quality can vary substantially, as the price differentials indicate.

METHODOLOGY

Demand Estimation

With horse, dairy, and beef animals utilizing alfalfa, divergent feed requirements must be considered. Thus, alfalfa demand estimations for each animal type were determined. These demand estimates were contingent upon specified maintenance requirements and formulated by a least cost criterion where applicable.

A feed mix model utilizing linear programming procedures was used for alfalfa hay demand estimations in dairy and horse enterprises. Demand for alfalfa hay for beef was exacted via a different approach since beef feeders are less likely to balance feed rations. The procedure used to estimate alfalfa demand is explained later.

Feed Mix Modeling

Linear programming (LP) was utilized to estimate an optimal feed mix with respect to dairy and horse enterprises. A ration was formulated contingent upon the maintenance requirements relative to animal type. A feed mix linear programming model was used to estimate the daily demand of alfalfa for the average horse and dairy cow vis-a-vis nutrient constraints. Once a daily alfalfa requirement was obtained, the price of alfalfa was varied to elicit individual daily demand equations. Finally, the daily requirements were used to calculate annual state-wide alfalfa demand.

Linear programming was selected for this estimation because it optimizes an objective function at least cost pursuant to prespecified constraints. These constraints can be maximums, minimums, equalities, ratios, and ranges of components and/or nutrients. Being able to vary feed ingredients and their input levels is important in ascertaining a balanced feed ration at least cost.

The feed mix model constraints were of two types: physical and nutritional. Physical constraints restricted the daily volume of feed consumption to meet the animal's digestive capacity. Nutritional constraints assured the daily maintenance requirements were met for each animal type.

Assumptions of Feed Mix Model

1. The farmer's priority is to find rations that fulfill the nutritional requirements contingent upon animal type.
2. The farmer's objective is to balance the ration at least cost.

3. Tastes and preferences are not considered when deciding the quantities of raw materials used.
4. The model does not consider labor, storage or fixed costs when deciding the quantities of raw materials used.
5. The model assumes that all the individual animals of each operation are homogeneous with respect to their nutritional requirements. Needs do not vary with respect to age, sex, work level, or location.
6. The prices and nutritional content of the feed stuffs do not vary except when specified.
7. All silage in the rations is purchased or valued at a purchase price.

Beef Demand Procedure

The beef demand estimates for alfalfa were found by other means. Unlike their counterparts, beef feeders normally do not balance rations. Crampton and Harris (1969) state "there is no fixed pattern of a balanced ration for beef cattle because most of the situations that require protein supplements to the roughage call for relatively little extra energy." Ensminger (1976) states, "Generally speaking cattle feeders utilize those roughages that are most readily available and lowest in price." With alfalfa prices usually higher than other forages, beef feeders will substitute less expensive forage types. However, certain beef types are fed alfalfa. State-wide demands for alfalfa were found by determining these beef types, their numbers, and usage rates.

MODELS & RESULTS

Dairy Feed Mix Model

This model was developed based on the requirements of an average Holstein cow weighing between 1200 and 1300 pounds, producing 50 pounds of milk daily, with a 3.5% butter fat content.[1] Appendix table 1 presents the nutritional requirements recommended by Dr. Dan Riddell, former U.K. Extension Dairy Specialist. Constraints upon forage intake were mandated to stay within the animal's digestive capacity. Furthermore, the maximum forage intake allowed increased with forage quality increases. Church and Pond (1982) state "The total feed consumption of cattle is highly dependent upon the quality of the roughage being consumed." Maximum constraints for varying alfalfa quality levels were derived from a dry matter intake formula.

The composition of each potential feed ingredient is given in table 1. Alfalfa was not specified because it was valued at three quality levels: low, medium, and high. Low and high quality alfalfa composition closely followed the 1978 National Research Council (NRC) Dairy Cattle Literature for sun-cured full bloom alfalfa hay, and first cutting early vegetative hay,

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1/The dairy model excludes dairy heifer replacements. However the feed requirements for the dairy cow were sufficiently high to account for part of the expected consumption by dairy heifer replacements. It was estimated that it would take 2,041 pounds of alfalfa to raise a dairy heifer to her first calving period. Not all of the dairy heifers would be fed alfalfa.

TABLE 1: COMPOSITION OF FEEDS (DRY MATTER BASIS) USED IN DAIRY FEED MIX

	CORN	SILAGE	SOYMEAL	FESCUE	LIMESTONE	DICALCIUM PHOSPHATE
CRUDE PROTEIN (%)	10.0	8.1	49.6	10.3	----	----
CALCIUM (%)	.03	.27	.36	.33	.36	.22
PHOSPHORUS (%)	.31	.26	.75	.24	----	.18
NET ENERGY OF LACTATION (Mcal/lb)	.92	.69	.85	.49	----	----
PRICE/POUND ($)	.07416	.0357	.1189	.06475	.029	.1545

respectively. Medium quality alfalfa was derived from an average of numerous Kentucky alfalfa samples submitted to the University of Kentucky's forage testing lab during 1985-86. The specifications of each quality level are given in table 2.

Table 3 presents the coefficients and format of the dairy feed mix model. The coefficients represent specific quantities of components per pound of input. Matching constraints were expressed in required pounds, with net cost in dollars, and net energy in Mcals. The alfalfa coefficient column is blank since these values changed with variations in quality. Costs were also omitted since they were altered for the sensitivity analysis. Unit costs of alfalfa for the original runs are presented in table 2.

Ingredient prices were obtained from a 1982 Kentucky feed mill price sheet. The prices of silage and alfalfa were derived differently. An as-fed silage price (price paid by farmers) was obtained from dairy farmers in the Lexington, Kentucky, area. These prices were converted to a dry matter basis since nutrient composition of the feed stuffs was computed on a dry matter basis. Equitable prices for the different alfalfa grades (Table 2) were derived by a Relative Feed Value Program. The prices of soybean meal, shelled corn, and dicalcium phosphate with respect to dry matter, energy, protein, and phosphate content were examined to obtain different alfalfa grade prices. An overall 10% increase in dry matter was added because the Relative Feed Value Program did not emphasize fiber content, essential for dairy cattle health and milk production.

TABLE 2: COMPOSITION OF THE THREE SELECTED GRADES OF ALFALFA HAY

	LOW QUALITY	MEDIUM QUALITY	HIGH QUALITY
	---Percentage on a Dry Matter Basis----		
CRUDE PROTEIN	14.0	19.0	23.0
CALCIUM	1.10	1.20	1.50
PHOSPHORUS	.30	.34	.36
DIGESTIBLE ENERGY (Mcal/lb)	1.08	1.24	1.34
NET ENERGY OF LACTATION (Mcal/lb)	.55	.64	.69
PRICE PER POUND *	.0387	.0477	.054

* These prices are for the first runs of the models.

TABLE 3: COEFFICIENTS AND FORMAT FOR THE DAIRY FEED MIX MODEL

ALFALFA (X_1)	CORN (X_2)	SILAGE (X_3)	SOY (X_4)	FESCUE (X_5)	DICAL (X_6)	LIMESTONE (X_7)	TYPE*	RHS	IDENTIFICATION
___	.07416	.0357	.1189	.0647	.1545	.029	MIN	.	NET COST
___	.10	.081	.496	.103	0	0	GE	5.26	PROTEIN
___	.10	.081	.496	.103	0	0	LE	5.50	PROTEIN
___	.0003	.0027	.0036	.0033	.22	.36	GE	.26	CALCIUM
___	.0003	.0027	.0036	.0033	.22	.36	LE	100	CALCIUM
___	.0031	.0026	.0075	.0024	.18	0	GE	.160	PHOSPHORUS
___	.0031	.0026	.0075	.0024	.18	0	LE	.175	PHOSPHORUS
___	.92	.69	.85	.49	0	0	GE	25.6	NET ENERGY
___	.92	.69	.85	.49	0	0	LE	26.5	NET ENERGY
1	1	1	1	1	0	0	LE	40.0	FEED
1	0	1	0	1	0	0	GE	16.0	MINFORAGE
1	0	1	0	1	0	0	LE	___	MAXFORAGE

*"MIN" indicates a minimization problem
"GE" means "greater than or equal to"
"LE" means "less than or equal to"
"EQ" indicates a strict equality

Alfalfa Sub-table:

	LOW QUALITY	MEDIUM QUALITY	HIGH QUALITY
COST	___	___	___
PROTEIN	.14	.19	.23
CALCIUM	.011	.012	.015
PHOSPHORUS	.003	.0034	.0036
NET ENERGY	.55	.64	.69
FEED	1	1	1
MAXIMUM FORAGE CONSTRAINT	24	26	28

Dairy Model Results

The three base solutions presented in table 4 were based upon the previously specified alfalfa grades given in table 2. Alfalfa was utilized in two of the three base solutions.

Low quality alfalfa specified in solution I valued at $77.40 per ton was not economical relative to its feed value. Corn silage usage was maximized due in part to its feed value possibly being underpriced.

Amount of alfalfa used in solution II (20.2 pounds) was relatively high compared to solution I and III. Medium quality alfalfa priced at $95.40 per ton replaced soybean meal and limestone to meet the crude protein and calcium requirements. Almost ten pounds of alfalfa were utilized in solution III when valued at $108 per ton.

These results suggest that as quality improves alfalfa usage will increase as long as the added nutrient gains exceed or equal their cost, i.e., marginal revenue $\geq$ marginal cost.

Alfalfa Price Changes

Twenty different alfalfa prices were used in each of the three dairy feed models to generate a demand schedule. Table 5 presents the prices used for cases 1 through 20. The results of these price variations for each quality level are given in table 6.

Results indicate that low quality alfalfa priced at or above $70 per ton was overvalued. At the prices mentioned earlier, corn silage, soybean meal, and limestone were substitutes for low

TABLE 4: BASE SOLUTIONS FOR THE DAIRY FEED MIX PROBLEMS

	SOLUTION I LOW QUALITY	SOLUTION II MEDIUM QUALITY	SOLUTION III HIGH QUALITY
	------------------	Pounds	------------------
ALFALFA	0	20.285718	9.633008
CORN SILAGE	24.0	5.714282	18.366992
SOYBEAN MEAL	5.781323	0	2.165648
CORN	4.484648	9.728572	4.825217
FESCUE	0	0	0
LIMESTONE	.343723	0	0
DICALCIUM PHOSPHATE	.224098	.260794	.257592

TABLE 5: ALFALFA PRICES (DRY MATTER BASIS) USED IN DAIRY FEED MODELS

Case 1: $10/ton = $.005/lb	Case 11: $110/ton = $.055/lb
Case 2: $20/ton = $.01/lb	Case 12: $120/ton = $.06/lb
Case 3: $30/ton = $.015/lb	Case 13: $130/ton = $.065/lb
Case 4: $40/ton = $.02/lb	Case 14: $140/ton = $.07/lb
Case 5: $50/ton = $.025/lb	Case 15: $150/ton = $.075/lb
Case 6: $60/ton = $.03/lb	Case 16: $160/ton = $.08/lb
Case 7: $70/ton = $.035/lb	Case 17: $170/ton = $.085/lb
Case 8: $80/ton = $.04/lb	Case 18: $180/ton = $.09/lb
Case 9: $90/ton = $.045/lb	Case 19: $190/ton = $.095/lb
Case 10:$100/ton= $.05/lb	Case 20: $200/ton = $.100/lb

TABLE 6: EFFECTS OF ALFALFA'S PRICE ON DAIRY RATIONS

Quality	Cases	Feed	---Pounds---
Low Quality	Cases 1 through 6:	Alfalfa	24.0
		Corn	12.214263
		Soybean	1.368094
		Dicalcium	.221528
	Cases 7 through 20:	Alfalfa	0
		Corn	4.484648
		Soybean	5.781323
		Silage	24.0
		Dicalium	.224098
		Limestone	.343723
Medium Quality	Cases 1 through 6:	Alfalfa	24.0
		Corn	9.542554
		Silage	3.617018
		Dicalcium	.249510
	Cases 7 through 9:	Alfalfa	20.285718
		Corn	9.728572
		Silage	5.714282
		Dicalcium	.260794
	Cases 10 through 20:	Alfalfa	0
		Corn	3.012117
		Silage	26.0
		Soybean	5.751591
		Limestone	.331647
		Dicalcium	.221809
High Quality	Cases 1 through 7:	Alfalfa	17.110017
		Corn	6.826087
		Silage	10.889983
		Dicalcium	.271829
	Cases 8 through 10:	Alfalfa	15.499279
		Corn	6.826087
		Silage	12.500721
		Dicalcium	.280777
	Case 11:	Alfalfa	9.633008
		Corn	4.825217
		Silage	18.366992
		Soybean	2.165648
		Dicalcium	.257592
	Cases 12 through 20:	Alfalfa	0
		Corn	1.539587
		Silage	28.0
		Soybean	5.721859
		Dicalcium	.219519
		Limestone	.319570

quality alfalfa. At prices below $70 per ton, low quality alfalfa was the price competitive forage. Usage of medium quality alfalfa was the same as low quality alfalfa when priced at or below $60 per ton. However, unlike low quality alfalfa, medium quality alfalfa remained in the ration up to $90 per ton before being replaced entirely by corn silage. Thus, the increased nutrient benefits from medium quality alfalfa priced from $70 to $90 per ton exceeded the proportional costs of low quality alfalfa when compared to corn silage. Medium quality alfalfa was forced out of the ration when priced at or above $100 per ton. High quality alfalfa was used at reduced rates compared to low and medium quality alfalfa when priced at or below $80 per ton.

Greater protein levels found in high quality alfalfa met the ration's protein requirements sooner, reducing the quantity of higher quality alfalfa needed compared to a lower protein source. Furthermore, high quality alfalfa remained in the rations at the highest price level, i.e., $110 per ton. This indicates that the marginal cost of protein was lower at the $110 per ton level than the lower quality alfalfa levels examined, with high quality alfalfa still competitively priced relative to its substitutes. High quality alfalfa priced at or above $120 per ton was not economical and did not enter the ration.

Sensitivity Analyses

Two types of sensitivity analyses were tested using medium quality alfalfa. Price and righthand-side sensitivity were used to evaluate the contributions of variable changes on the optimal solution.

Price sensitivity was run for medium quality alfalfa costing \$80 per ton. This determined the objective range by variable with changes in unit price. The objective range is the range over which a particular objective coefficient can be varied; all other coefficients and values remain unchanged (Bradley et al., 1977). The analysis was run on corn silage, corn, soy, fescue, dicalcium phosphate, and limestone, in order to find the objective range for unit prices. The objective range for corn silage was \$.021 to \$.056 per pound. Silage does not appear to be undervalued at \$.0357 per pound since it falls in the center of the objective range.

Price sensitivity analysis performed on corn displayed an objective range of \$.046 and \$.092 per pound. Thus, corn is priced reasonably given its objective range.

Fescue, not used in the feed ration, would enter the model at \$.0187 per pound, representing about thirty percent of the value used in the model. This indicates an overvaluation of fescue's nutrient content in relation to the other substitutes examined.

Dicalcium phosphate displayed an objective range of \$0 to \$.15486 per pound. Priced at \$.1545 per pound, dicalcium phosphate is near its upper range. Thus, an increase of \$.0003 per pound in dicalcium phosphate would cause a new variable to enter into the solution to keep the optimal solution constant.

Righthand-side sensitivity was tested on the maximum forage vector since it often constrained alfalfa usage. The righthand-side range is the range over which an individual righthand-side value can be varied, all the other variables being held constant, such that variables constituting the basis remain the same (Bradley et al., 1977). At the lower bound, silage was the "leaving variable." The leaving variable is the variable that reaches either the lower or upper bound in order to maintain the optimal solution. Corn was the exiting variable at the upper bound.

State-Wide Dairy Demand

Medium quality alfalfa was selected to generate the demand estimates. Dairy farmers indicated a preference for medium quality alfalfa rather than the expensive higher quality hay. Thus, dairy farmers are willing to substitute other forages to achieve balanced, least cost rations.

The 1985 average of monthly alfalfa hay prices was $74.56 per ton on an as-fed basis or $87.71 per ton on a dry matter basis. Thus, the ration that fell within the $70 to $90 range was used to derive the state-wide demand estimations. Alfalfa levels were rounded from 20.2 pounds to 20 pounds to ease calculations without any real loss of accuracy. Dairy cow populations by state from the 1982 Census of Agriculture were used. Daily alfalfa requirements times 365 days times the number of dairy cows per state represented state-wide demands (Table 7).

TABLE 7: ESTIMATED POTENTIAL ALFALFA CONSUMPTION BY DAIRY CATTLE BY STATE (1982)

State	Dairy Cow Population (Head)	Alfalfa Consumption (Tons of Medium Quality)
Alabama	58,946	215,153
Alaska	963	3,515
Arizona	81,811	298,610
Arkansas	86,779	316,743
California	946,201	3,453,634
Colorado	76,279	278,418
Connecticut	51,795	189,052
Delaware	9,956	36,339
Florida	194,550	710,108
Georgia	130,542	476,478
Hawaii	12,767	46,600
Idaho	178,082	649,999
Illinois	206,827	758,919
Indiana	188,716	688,813
Iowa	339,664	1,239,774
Kansas	123,009	448,983
Kentucky	253,852	926,560
Louisiana	100,159	365,580
Maine	57,173	208,681
Maryland	128,183	467,868
Massachusetts	49,891	182,102
Michigan	398,211	1,453,470
Minnesota	839,302	3,063,452
Mississippi	96,224	351,218
Missouri	267,753	977,298
Montana	29,447	107,482
Nebraska	117,536	429,006
Nevada	15,851	57,856
New Hampshire	30,984	113,092
New Jersey	38,792	141,591

TABLE 7, CONTINUED:

State	Dairy Cow Population	Alfalfa Consumption
New Mexico	53,877	196,651
New York	875,113	3,194,162
North Carolina	125,832	459,287
North Dakota	102,660	374,709
Ohio	368,601	1,345,394
Oklahoma	108,021	394,277
Oregon	99,134	361,839
Pennsylvania	690,779	2,521,343
Rhode Island	3,872	14,133
South Carolina	47,559	173,590
South Dakota	158,180	577,357
Tennesse	217,234	792,904
Texas	323,039	1,179,092
Utah	90,108	328,894
Vermont	191,089	697,475
Virginia	173,418	632,976
Washington	210,254	767,427
West Virginia	34,776	126,932
Wisconsin	1,852,784	6,762,662
Wyoming	13,315	48,600
U.S. Totals	10,849,888	39,606,098

Horse Feed Mix Model

The horse feed mix model was based on the maintenance levels for a mature horse weighing 500 Kilograms (1102.3 lb). Constraints were specified for calcium, phosphorus, protein (on a dry matter basis), and digestible energy in Mcals. A calcium-phosphorus constraint was added (CP balance) to ensure a minimum 1:1 ratio of calcium to phosphorus. The absorption of calcium by horses is restricted when the intake of phosphorus exceeds that of calcium (National Academy of Sciences, 1978). Bone problems often occur from inadequate calcium or an unbalanced ratio.

Feed ingredients were recommended by Dr. Steve Jackson, U.K. Horse Production Extension Specialist. The five ingredients were: alfalfa, corn, oats, soybean meal, and timothy hay. The daily nutritional requirements are given in appendix table 1. Ingredient compositions in terms of nutritional constraints, along with price, are presented in table 8. The three alfalfa quality levels used for dairy (Table 2) were also used for the horse model base solutions.

Horse Model Results

The three base solutions required 16.4 pounds of alfalfa daily regardless of quality and price. Even though the rations mandated sole usage of alfalfa, many horse farmers do not feed pure hay but a mixture of concentrates and forages. The ratio of concentrates and forages varies with stage of maturity, work level, and other factors.

However, adjustments were not made for forage and concentrate ratios since the 16.4 pounds of alfalfa represented the least cost maintenance level. "Experience on thousands of

TABLE 8: COMPOSITION OF FEEDS (DRY MATTER BASIS) USED IN HORSE FEED MIX

	CORN	OATS	SOYBEAN MEAL	TIMOTHY HAY
CRUDE PROTEIN (%)	10.9	13.6	50.9	9.0
CALCIUM (%)	.05	.07	.31	.41
PHOSPHORUS (%)	.6	.37	.70	.19
DIGESTIBLE ENERGY (Mcal/lb)	3.87	3.34	3.6	1.98
PRICE/lb ($)	.07416	.1348	.1189	.112

farms in the western part of the United States, where alfalfa has been used for many years as the only roughage for horses and mules, shows that it is economical and entirely satisfactory when properly fed" (Morrison, 1956).

Two factors may have influenced the sole usage of alfalfa. First, levels of calcium to phosphorus (CP) were required to be positive. Only timothy and alfalfa have positive (CP) ratios with respect to the other ingredients used. Thus, hay was required. Second, all three quality levels of alfalfa were nutritionally superior to timothy on a dry matter basis (Tables 2 & 8). Therefore, alfalfa was selected over timothy at comparable prices.

<u>Alfalfa Price Changes</u>

Three horse models were run at twenty different alfalfa prices (Table 5) to generate a demand schedule. Sensitivity analysis revealed one ration change for each hay grade. When alfalfa prices reached $160 per ton, the rations changed from pure alfalfa to a mix of corn and alfalfa (Table 9). Different alfalfa quality levels beyond the $180 level displayed varying usage rates. The (CP) ratio kept alfalfa in the model since corn has a negative (CP) ratio (i.e., corn has more phosphorus than calcium).

<u>State-Wide Horse Demand</u>

Horse and pony populations were obtained for each state (1982 Census of Agriculture: 1985). These populations were multiplied by 365 days and 16.4 pounds of alfalfa to arrive at annual state-wide demand. Alfalfa demand estimates for horses are shown in table 10.

TABLE 9: THE EFFECTS OF ALFALFA'S PRICE ON HORSE RATIONS

Low Quality:

Cases 1 through 15:

Alfalfa	16.4	pounds

Cases 16 through 20:

Alfalfa	9.718517	lbs.
Corn	6.681483	lbs.

Medium Quality:

Cases 1 through 15:

Alfalfa	16.4	lbs.

Cases 16 through 20:

Alfalfa	6.397165	lbs.
Corn	10.002835	lbs.

High Quality:

Cases 1 through 15:

Alfalfa	16.4	lbs.

Cases 16 through 20:

Alfalfa	5.337278	lbs.
Corn	11.062722	lbs.

TABLE 10: ESTIMATED POTENTIAL ALFALFA CONSUMPTION BY HORSES BY STATE

State	Horse Population (Head)	Alfalfa Consumption (Tons)
Alabama	27,106	81,128
Alaska	2,528	7,566
Arizona	39,464	118,116
Arkansas	38,827	116,209
California	129,310	387,025
Colorado	72,173	216,014
Connecticut	5,602	16,767
Delaware	3,514	10,517
Florida	47,431	141,961
Georgia	26,607	79,635
Hawaii	4,030	12,062
Idaho	55,041	164,738
Illinois	58,397	174,782
Indiana	51,799	155,034
Iowa	68,368	204,625
Kansas	60,285	180,433
Kentucky	78,569	235,157
Louisiana	36,119	108,104
Maine	5,498	16,456
Maryland	22,801	68,243
Massachusetts	8,765	26,234
Michagan	52,648	157,575
Minnesota	53,945	161,457
Mississippi	26,273	78,635
Misouri	76,977	230,392
Montana	68,911	206,251
Nebraska	51,623	154,508
Nevada	15,124	45,266
New Hampshire	3,667	10,975
New Jersey	18,817	56,319

Table 10, CONTINUED:

State	Horse Population	Alfalfa Consumption
New Mexico	53,295	159,512
New York	48,059	143,841
North Carolina	27,509	82,344
North Dakota	35,378	105,886
Ohio	76,514	229,006
Oklahoma	90,654	271,327
Oregon	56,927	170,383
Pennsylvania	66,042	197,664
Rhode Island	782	2,341
South Carolina	12,606	37,730
South Dakota	47,982	143,610
Tennesse	53,951	161,475
Texas	233,202	697,974
Utah	33,006	98,787
Vermont	7,160	21,430
Virginia	42,217	126,355
Washington	52,404	156,980
West Virginia	14,957	44,766
Wisconsin	50,409	150,874
Wyoming	47,608	142,491
U.S. Total	2,260,881	6,766,960

Beef Demand Procedure

Two beef types are generally recognized as being ideal consumers of alfalfa hay--stockers and cows. "Stockers are young heifer replacements or steers and heifers that are intended for market and which are being fed and cared for in such a manner that growth rather than fattening may be realized" (Ensminger 1976). This type of feeding program is often referred to as backgrounding.

The number of stocker cattle inventory by state was found by finding the sum of: steers and heifers (non-replacement) over 500 pounds, and animals under 500 pounds. This represented the gross number of cattle not used for breeding. The number of cattle on feed as of January 1 for a given year was subtracted from the gross supply. The remainder represented the inventory of beef cattle outside of feedlots assuming that the quantity of cattle on feed represented the total supply being fattened for slaughter. The populations of stockers and beef cows by state are presented in table 11.

The formulas used to estimate demand for alfalfa hay by user group are now specified.

Beef Cow Usage = (# cows) (60 days) (5.5 lbs) + (# cows)
(90 days) (9 lbs)

Stocker Usage = (# calves) (150 days) (.4166) (6 lbs)

Time periods and rates used in each formula are as follows.

Beef Cow Formula

The beef cow formula has two parts: 1) pre-calving, and 2) post-partum. The pre-calving segment represents the number of beef cows per state, length of feeding period, and quantity fed

TABLE 11: BEEF COWS AND STOCKER CATTLE BY STATE 1982

State	Cows (Head)	Stocker Cattle (Head)
Alabama	785,032	655,000
Alaska	2,994	3,000
Arizona	313,040	221,000
Arkansas	819,320	684,000
California	952,164	1,599,000
Colorado	847,010	935,000
Connecticut	6,746	28,000
Delaware	5,129	14,000
Florida	1,098,052	533,000
Georgia	690,184	629,000
Hawaii	90,523	84,000
Idaho	614,385	650,000
Illinois	622,002	1,024,000
Indiana	377,741	649,000
Iowa	1,536,397	3,158,000
Kansas	1,523,697	2,560,000
Kentucky	982,794	963,000
Louisiana	480,918	396,000
Maine	13,242	38,000
Maryland	52,151	100,000
Massachusetts	8,176	22,000
Michagan	140,969	481,000
Minnesota	467,732	1,519,000
Mississippi	713,119	621,000
Missouri	1,933,477	2,302,000
Montana	1,528,036	810,000
Nebraska	2,023,618	2,856,000
Nevada	285,594	216,000
New Hampshire	4,526	21,000
New Jersey	11,622	24,000

TABLE 11, CONTINUED:

State	Cows (Head)	Stocker Cattle (Head)
New Mexico	597,132	594,000
New York	77,712	442,000
North Carolina	342,296	379,000
North Dakota	874,660	693,000
Ohio	316,523	685,000
Oklahoma	1,830,253	2,525,000
Oregon	656,150	688,000
Pennsylvania	174,078	653,000
Rhode Island	1,251	2,000
South Carolina	226,482	221,000
South Dakota	1,595,688	1,475,000
Tennesse	914,784	855,000
Texas	5,223,321	4,240,000
Utah	320,470	303,000
Vermont	9,473	72,000
Virginia	617,787	661,000
Washington	339,997	539,000
West Virginia	198,322	205,000
Wisconsin	236,967	1,370,000
Wyoming	718,771	469,000
United States	34,202,607	40,846,000

per day. Sixty days was designated for the length of feeding. Minish and Fox (1979) indicate that good quality hay is needed sixty days prior to calving for maintenance and rapid fetal growth. In determining the amount to be fed daily, Ensminger (1976) indicates that pregnant cows in medium to good condition in the fall can be wintered satisfactorily on straw plus 4 to 5 pounds of alfalfa or other legume hay. The daily amount of alfalfa fed was chosen at 5.5 lb to meet the pre-calving requirements.

The post-partum portion of the formula consists of the number of beef cows per state, length of feeding, and the amount fed daily. A 90 day feeding period was recommended by Drs. W. Roy Burris and Garry Lacefield (KAC 1986). The quantity fed daily was set at nine pounds based on Minish and Fox's (1979) recommendation of 8 to 10 lb of alfalfa plus full feed silage or good quality pasture.

Stocker Calf Formula

Replacement heifers and market-bound stocker cattle, length of feeding period, percent of stocker cattle consuming alfalfa, and the daily quantity of alfalfa fed are the variables in the stocker calf formula. Ensminger (1976) suggests feeding forage, supplemental concentrates when necessary during the winter, and grazing in the summer. A 150-day feeding period was deemed appropriate to represent the length of feeding during the winter months. The percent of stocker cattle fed was chosen based upon Dr. Nelson Gay's (University of Kentucky Beef Specialist) suggestion that 33 to 50% of all stockers consume alfalfa. Thus, an average of 41.66% was calculated and used as the percent of stockers utilizing alfalfa. Six pounds of alfalfa was fed daily. Fowler (1969) and Jurgenson (1964) recommended feeding six pounds of good legume hay daily to young steers.

Estimated demand for alfalfa hay by beef operations is presented in table 12. Specifically, the alfalfa demanded by beef cows and stockers for each state is given as well as the total alfalfa demanded.

CONCLUSIONS

Estimates of aggregated alfalfa demand by state for horse, beef and dairy enterprises are given in table 13. Additionally, deficit or surplus alfalfa states, based on 1982 demand estimates and production levels, are shown. The southeastern states represented a deficit alfalfa region. Production levels for some southeastern states (Alabama, Florida, Georgia, Mississippi, and South Carolina) were not specified indicating sparse or nonexistent alfalfa production. Total U.S. alfalfa demand was 73.53 million tons, which represented 83 % of total U.S. alfalfa production (USDA Agricultural Statistics: 1984). Table 14 specifies by state the percentage of total alfalfa demanded by user type. Dairy was the primary enterprise demanding alfalfa in 27 states, with beef and horse types predominant in 21 and one states, respectively.

The difference between demand and supply in table 13 revealed an excess supply of 14,856 tons in 1982--or 20%. However, the 1982 production level of 88,385 tons does not account for post-harvest losses such as wastage during feeding, mold, rodents, and weather. Thus, an "effective" supply would be

TABLE 12: ESTIMATED ALFALFA HAY USE BY BEEF OPERATIONS IN 1982

STATE	COWS (Tons)	STOCKERS (tons)	STATE TOTAL (tons)
Alabama	447,468	122,793	570,261
Alaska	1,707	562	2,269
Arizona	178,433	41,431	219,864
Arkansas	467,012	128,229	595,241
California	542,733	299,765	842,498
Colorado	482,796	175,284	658,080
Connecticut	3,845	5,249	9,094
Delaware	2,924	2,625	5,549
Florida	625,890	99,922	725,812
Georgia	393,405	117,919	511,324
Hawaii	51,598	15,747	67,345
Idaho	350,199	121,856	472,055
Illinois	354,541	191,969	546,510
Indiana	215,312	121,668	336,980
Iowa	875,746	592,030	1,467,776
Kansas	868,507	479,923	1,348,430
Kentucky	560,193	180,534	740,727
Louisiana	274,123	74,238	348,361
Maine	7,548	7,124	14,672
Maryland	29,726	18,747	48,473
Massachusetts	4,660	4,124	8,784
Michigan	80,352	90,173	170,525
Minnesota	266,607	284,767	551,374
Mississippi	406,478	116,419	522,897
Missouri	1,102,082	431,556	1,533,638
Montana	870,981	151,851	1,022,832
Nebraska	1,153,462	535,414	1,688,876
Nevada	162,789	40,494	203,283
New Hampshire	2,578	3,937	6,515
New Jersey	6,625	4,499	11,124

TABLE 12, CONTINUED:

State	Cows (tons)	Stockers (tons)	State Total (tons)
New Mexico	340,365	111,357	451,722
New York	44,296	82,862	127,158
North Carolina	195,109	71,051	266,160
North Dakota	498,556	129,917	628,473
Ohio	180,418	128,417	308,835
Oklahoma	1,043,244	473,362	1,516,606
Oregon	374,006	128,979	502,985
Pennsylvania	99,224	122,418	221,642
Phode Island	713	375	1,088
South Carolina	129,095	41,431	170,526
South Dakota	909,542	276,518	1,186,060
Tennessee	521,427	160,287	681,714
Texas	2,977,293	794,873	3,772,166
Utah	182,668	56,803	239,471
Vermont	5,400	13,498	18,898
Virginia	352,139	123,918	476,057
Washington	193,798	101,046	294,844
West Virginia	113,044	38,431	151,475
Wisconsin	135,071	256,834	391,905
Wyoming	409,699	87,923	497,622
U.S. Totals	19,145,228	7,284,324	26,429,552

TABLE 13: ALFALFA HAY DEMAND ESTIMATES AND PRODUCTION *BY STATE, 1982

State	Demand (1,000 tons)	Production (1,000 tons)	Deficit/Surplus (1,000 tons)
Alabama	867	NA	---
Alaska	13	NA	---
Arizona	637	1,168	531
Arkansas	1,028	120	(908)
California	4,683	6,432	1,749
Colorado	1,153	2,201	1,048
Connecticut	215	63	(152)
Delaware	52	27	(25)
Florida	1,578	NA	---
Georgia	1,067	NA	---
Hawaii	126	NA	---
Idaho	1,287	3,774	2,487
Illinois	1,480	2,691	1,211
Indiana	1,181	1,463	282
Iowa	2,912	6,630	3,718
Kansas	2,978	3,650	1,672
Kentucky	1,902	810	(1,092)
Louisiana	822	31	(791)
Maine	240	65	(175)
Maryland	585	270	(315)
Massachusetts	217	81	(136)
Michigan	1,782	3,675	1,893
Minnesota	3,776	6,240	2,464
Mississippi	953	NA	---
Missouri	2,741	1,566	(1,175)
Montana	1,337	3,375	2,038
Nebraska	2,272	5,440	3,168
Nevada	306	821	515
New Hampshire	131	49	(82)
New Jersey	209	175	(34)
New Mexico	808	1,250	442
New York	3,465	2,633	(832)
North Carolina	808	88	(720)
North Dakota	1,109	3,100	1,991
Ohio	1,883	1,715	(168)
Oklahoma	2,182	1,221	(961)
Oregon	1,035	1,764	729
Pennsylvania	2,941	2,520	(421)
Rhode Island	18	8	(10)
South Carolina	382	NA	---
South Dakota	1,907	4,950	3,043
Tennessee	1,636	390	(1,246)

TABLE 13, CONTINUED:

State	Demand Estimates	Production	Deficit/Surplus
Texas	5,649	828	(4,821)
Utah	667	1,880	1,213
Vermont	738	297	(441)
Virginia	1,235	304	(931)
Washington	1,219	1,840	621
West Virginia	323	234	(89)
Wisconsin	7,305	11,133	3,828
Wyoming	689	1,413	724
U.S. Totals	73,529	88,385	14,856

*Alfalfa and Alfalfa Mixtures

NA = No Data Available

Source: USDA Agricultural Statistics, 1984

TABLE 14: PERCENTAGE OF ALFALFA DEMANDED BY ANIMAL GROUP PER STATE

STATE	BEEF	DAIRY	HORSE
	-----------	percent	-----------
Alabama	66	26	9
Alaska	17	26	57
Arizona	35	47	18
Arkansas	58	31	11
California	18	74	8
Colorado	57	24	19
Connecticut	5	88	7
Delaware	11	69	20
Florida	46	45	9
Georgia	48	45	7
Hawaii	53	37	10
Idaho	37	51	12
Illinois	37	51	12
Indiana	29	58	13
Iowa	50	43	7
Kansas	68	23	9
Kentucky	39	49	12
Louisiana	42	45	13
Maine	6	87	7
Maryland	8	80	12
Massachusetts	4	84	12
Michigan	10	82	8
Minnesota	15	81	4
Mississippi	55	37	8
Missouri	56	37	7
Montana	77	8	15
Nebraska	74	19	7
Nevada	66	19	15
New Hampshire	5	87	8
New Jersey	5	68	27
New Mexico	56	24	20
New York	4	92	4
North Carolina	33	57	10
North Dakota	57	34	9
Ohio	16	71	12
Oklahoma	69	18	13
Oregon	49	35	16
Pennsylvania	8	86	6
Rhode Island	6	80	14

TABLE 14, CONTINUED:

State	Beef	Dairy	Horse
	--------percent--------		
South Carolina	45	46	9
South Dakota	62	30	8
Tennessee	42	48	10
Texas	67	21	12
Utah	36	49	15
Virginia	39	51	10
Washington	24	63	13
West Virginia	47	39	14
Wisconsin	5	93	2
Wyoming	72	7	21

closer to estimated demand reducing the magnitude between the two.

Demand estimates need to be viewed within the constraints of the modeling technique. For example, beef demand estimates for alfalfa did not reflect quality variations, price, or substitutes when determining alfalfa usage. Furthermore, changes in prices of feed substitutes and livestock numbers are dynamic variables influencing annual alfalfa demand. With respect to the study's constraints, a more succinct conclusion can still be drawn as to the quantities demanded of alfalfa by state. Implications regarding alfalfa's cash crop potential can also be rendered when evaluating total demand and supply respective to a geographic area. The southeast states (Kentucky, Tennessee, Mississippi, Alabama, Georgia, Florida, North Carolina, South Carolina, and Louisiana) accounted for 14 percent of this study's total 1982 U.S. alfalfa demand. However, these states represented only 1.5 percent of the total 1982 U.S. alfalfa production (USDA Agricultural Statistics: 1984). Certainly, alfalfa's potential as a cash crop is worthy of investigation as a viable alternative in certain areas. However, additional research using more individual state data needs to be conducted before reaching a definite conclusion.

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APPENDIX

Appendix Table 1

Daily Nutritional Requirements for a Dairy Cow[1] and Horse[2]

Requirements	Dairy Cow	Horse
Crude Protein (CP)	5.26 lb < CP < 5.5 lb	CP > 1.39 lb
Calcium (Ca)	Ca > .26 lb	Ca > .0507 lb
Phosphorus (P)	.16 lb < P < .175 lb	P > .0308 lb
Total Dry Matter (TDM)	TDM < 40 lb	TDM = 16.4 lb
Net Energy of Lactation (NEL)	25.6 Mcals < NEL < 26.5 Mcals	N/A
Total Forage Constraint (TFC)	16 lb < TFC < 24 lb for (LQF)* < 26 lb for (MQF)* < 28 lb for (HGF)*	N/A

[1]Based on an average Holstein Cow, 1200-1300 lbs. maintenance, 3.5% butter fat, 50 lb production.

[2]Based on a mature horse at maintenance 500Kg mature weight (1102.3 lb).

*LQF = Low quality forage
MQF = Medium quality forage
HQF = High quality forage

Sources: Dr. Dan Riddel, Former Extension Dairy Specialist, University of Kentucky.

Dr. Steve Jackson, Extension Horse Production Specialist University of Kentucky.

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