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Demand for Alfalfa Hay in California

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I. INTRODUCTION

PURPOSE OF THE STUDY

Alfalfa is one of the most important crops in California, averaging some 15 percent of total field crop acreage and generating 17 percent of total value of field crop production in California between 1979-82 (California Crop and Livestock Reporting Service (CCLRS), *Field Crop Review,* Federal-State Market News Service (MNS), *Alfalfa Hay: California Market Summary.* In 1980 alfalfa and other hay ranked first among field crops in California in terms of acreage and second in value of production (Nuckton and Johnston, 1983). Alfalfa is also a substantial water user accounting for approximately 18 percent of water applied in irrigated agriculture (California Department of Water Resources, 1982) or roughly 15 percent of all water use in the state. Nationwide, alfalfa represented about 8 percent of all field crop acreage between 1979-82 (U.S. Department of Agriculture, 1983)

Despite its importance there are relatively few studies of the market for alfalfa, either in California or in other parts of the country. In a classic study Schultz (1938) provides estimates of nationwide demand for hay and other agricultural commodities for several time periods ending in 1929. Shumway, in a 1983 paper on Texas field crops, formulates the quantity of alfalfa supplied as a function of expected own- and competing-crop prices, input prices and fixed input quantities. In a 1974 study investigating the effects of government intervention in California field crop production desicions, Just uses the Nerlovian adaptive expectation - partial adjustment hypothesis for annual crops to formulate an alfalfa supply function. Blake and Clevenger (1984) combine an annual supply and demand model with a system of monthly equations to forecast alfalfa prices in New Mexico. Myer and Yanagida (1984) provide an econometric estimate of the demand for alfalfa in 11 western states and combine that demand relation with an ARIMA model to generate forecasts for quarterly alfalfa prices.

The purpose of this paper is to estimate the demand for alfalfa in California. The first approach is normative and is based on a detailed linear programming (LP) model developed at the University of California (UC), Davis for feeding dairy cattle. This LP model can be used for estimating alfalfa demand on an individual milk cow basis, and has the further advantage that it is actually being used by dairy farmers in their feeding decisions. Aggregate normative demand is then estimated using an extensive set of data on milk cow characteristics provided by the dairy industry and data on the numbers and quantities fed to other livestock.

The second approach is positive in that historical data are used to estimate alfalfa demand schedules econometrically as in Schultz (1938), Blake and Clevenger (1984), and Myer and Yanagida (1984); however, some alternative specifications are considered.

The demand estimates have a number of potential applications: forecasting alfalfa prices given production levels, forecasting long-run equilibrium levels of alfalfa production given production costs and cattle numbers, analyzing the effects of dairy price supports and water policies on the alfalfa market. The estimates are currently being used in a spatial equilibrium model of the California alfalfa market (Konyar, 1985; Konyar and Knapp, 1985). The procedures employed here could be used to estimate alfalfa demand in other areas and the derived demand for other inputs to the dairy industry. The empirical comparison of the normative and positive approaches to demand estimation may also be of interest.

NORMATIVE VERSUS POSITIVE APPROACHES TO DEMAND ESTIMATION

Shumway and Chang (1977) review the advantages and disadvantages of normative and positive approaches to estimating supply functions for agricultural commodities. The normative approach makes use of detailed data and knowledge of the industry which may not be capturable in an econometric analysis. The normative approach is also useful for analyzing conditions significantly different from those experienced historically—conditions which one would hesitate to extrapolate from more general statistical relations.

But the normative approach cannot incorporate all the relevant decisions, constraints, and options of the underlying behavioral model. For this econometrics is better suited being based more closely on observed behavior. Normative models often must use unverified behavioral assumptions and information sets, though in this study the dairy feeding model or a similar one is actually used by dairy farmers. A disadvantage of the econometric approach to demand estimation is that a relatively long time series is needed to obtain an adequate sample size. Changes in technology, management practices, or structure during this period may make forecasting the estimated demand curves unreliable. Time trends and other information used to adjust for these changes are likely to be imperfect in practice.

Ideally, all available information should be used in estimating demand relations, suggesting a combination of the two approaches. But as a practical matter, most economic studies estimating demand or supply relations choose one or the other. This study which uses both provides a direct comparison between them.

PLAN OF THE STUDY

Normative dairy cow demand functions for alfalfa are estimated in Section II. The demand for alfalfa by other livestock is assumed to be perfectly inelastic. Estimates of consumption are given in Section III, as is the aggregate normative demand function. Econometric estimates of statewide demand for alfalfa are given in Section IV. Section V compares the results from the two approaches. Section VI provides a summary and conclusion.

II. NORMATIVE ESTIMATES OF ALFALFA DEMAND BY MILK COWS

The dairy industry is the single largest user of alfalfa in California. Approximately 70 percent of California's alfalfa crop is fed to dairy livestock and about 71 percent of that amount or 50 percent of all alfalfa is consumed by milk cows. In this section we provide normative estimates of alfalfa demand by milk cows in four different regions and then generalize them for the remainder of milk cows in the state. Regional demand estimates reflect the differences in dairy management practices, milk prices, and prices of other feeds. First, general characteristics of the state's dairy industry and of the four regions are described. Alfalfa demand on an individual milk cow basis is estimated using an LP model developed at UC Davis and results are presented. The procedure for aggregating the individual-cow demand relations is then described, and the regional estimates given.

CHARACTERISTICS OF THE CALIFORNIA DAIRY INDUSTRY

Background and Terminology

In 1982, the California dairy industry with its 940 thousand milk cows and close to 2 billion sales, ranked second in the nation to Wisconsin in both animal numbers and revenue. California's dairy industry is the nation's most productive with an average milk output of 15, 446 pounds per cow. The size of a dairy farm varies from a few cows to over 4,000. There were 2,845 dairy farms in the state in 1983, with an average herd size of 330 cows (Siebert, 1983). While the number of farms has been declining over the years, the decrease has been more than offset by the increase in the average herd size, resulting in an increased number of dairy cows in the state.

The diversity across the state in climates, topography, soils, cropping patterns, etc., results in substantial variation in dairy famring methods. However, the State's dairy herd is relatively homogeneous biologically. Its components are:

- — cows, females who have calved,
- — calves, animals under one year old of either sex,
- — heifers, female calves between age one and two who have not yet calved,
- — bulls, uncastrated males of any age,
- — steers, castrated males of any age.

Of 1.65 million dairy cattle and calves in 1982, 57 percent were cows, 28 percent were replacement heifers and 15 percent were bulls, calves, or steers (calculated from CCLRS, *California Livestock Statistics,* 1982). Heifers kept as replacements are bred when they are two years old; after giving birth they begin their lactation period which lasts an average of 305 days. Towards the end of the second month of the lactation period they are bred again; about two months before giving birth, milking stops. These dry cows make up 15-20 percent of a herd at any given time. In general, a cow reaches her highest output at her third lactation, after which average cows are culled (Peterson, personal communication).

Feeding Dairy Cattle

Nutrition is of fundamental importance to milk production, maintenance, growth, reproduction, and health of a dairy cow. Feed costs typically comprise about 50-65 percent of total dairy production costs and are a major factor affecting the profitability of milk production.

Feeds for dairy cattle can be divided into (1) concentrates, feeds that are high in energy and usually low in fiber content, and (2) roughages, feeds that are bulky, relatively high in fiber, and low in energy. (Feeds 81 to 102 in Appendix Table 1, are roughages.) Cows need a certain amount of roughage to maintain a healthy existence, proper digestive functioning, and production of milk with acceptable fat content. Hay, pasture, and silage are forage crops commonly used as roughage feeds for dairy cows.

Alfalfa hay is the most widely used forage crop in California, making up approximately 85 percent of the hay fed to dairy cattle. Alfalfa is rich in protein, vitamins, calcium, potassium, and trace minerals and is slightly higher in energy value than most other forages. Because of its high nutritive value and its palatability, alfalfa is the main source of protein for California dairy herds and provides almost half the energy they consume (Pelissier and Bath, 1977, p. 21).

Alfalfa is also fed to dry cows, calves, replacement heifers, and bulls. During the time that cows are dry, they need energy and protein to replenish body reserves which are critical to their performance in the succeeding lactation period. The amount of alfalfa a dry cow should consume depends, among other things, on her condition at the end of lactation, desired weight gain, and other feeds provided. This study follows Pelissier and Bath (1977) in its assumption that a dry cow consumes the same amount of alfalfa as at the end of lactation.

Quality of Alfalfa Hay

Quality is an important determinant of the price dairy farmers are willing to pay for alfalfa. Alfalfa quality is measured by its nutrient content, i.e., energy, protein, minerals, and vitamins. Because energy is the nutrient most limiting to milk production, energy content is the most important parameter in evaluating alfalfa quality. High energy alfalfa is also high in protein. In measuring the quality of alfalfa, two analyses are conducted: determination of percent dry matter (% DM) and of modified crude fiber (MCF). From these two tests, estimated net energy (ENE), digestible protein (DP), and total digestible nutrient (TDN) values of alfalfa hay can be reliably predicted (Bath, Marble, Smith, 1978). (See also Pelissier and Bath, 1977, pp. 5-11, for a definition and discussion of the above nutrients. Table 2 in the Appendix lists the average nutrient analyses of various types of alfalfa hay and of other feedstuffs.)

Given soil and weather conditions, the quality of alfalfa depends largely on harvesting and postharvesting practices. The stage of maturity at which alfalfa is cut strongly influences its quality. Compared to other parts of the plant, the leaves are higher in protein and lower in fiber, so a pre-bud or early bud harvest has the most leaves and therefore highest quality. As alfalfa matures, it starts to lose the lower leaves, stems get thicker, protein declines, and fiber increases. However, continuously harvesting alfalfa in the early bud stage shortens the life of the stand resulting in reduced annual yields. Thus there is a tradeoff between yield and quality. Postharvest practices, including curing, baling, and handling, can greatly affect alfalfa quality. For this study alfalfa number 82, characterized in Appendix Table 2, is chosen as representative of the various qualities of alfalfa hay fed to dairy cows.

Consumption Regions

Four consumption regions are specified. Each is formed by several counties with large dairy cow populations surrounding a traditional alfalfa market center. The regions were defined to reflect differences in prices and availability of feedstuffs, in the price of milk, and in dairy management practices. These four regions contain 93 percent of California's milk cows (Table 1). Demand for alfalfa by the remainder of the state's milk cows is assumed to be similar to that in one of the four defined consumption regions.[1]

OPTIMUM ALFALFA CONSUMPTION PER COW

Model

Alfalfa demand on an individual milk cow basis is estimated with a normative model. The model was first developed by Dean et al. (1972), extended by Bath and Bennett (1980), and designed as a computer program by the Animal Science Extension unit at UC Davis, under the title "California Dairy Ration Program." The program is accessible through county dairy farm advisors for a small fee, and most of the state's dairy farmers use this or similar programs when formulating their rations. Therefore, it is believed that the results of the model are a very close approximation to dairy farmers' cattle feeding behavior.

The LP model maximizes income above feed costs:

$$\pi_m = P_m \cdot f(q_1, \ldots, q_n) - \sum_i P_i q_i$$

where:

π_m = profit per cow, \$/day

[1]The mountain counties of Siskiyou, Modoc, Shasta, and Lassen and the Sacramento Valley counties of Yuba, Tehema, Glenn, Butte, Colusa, Sutter, Yolo, and Solano were assumed to be similar to the North Valley region. The northern coastal counties of Del Norte, Humbolt, Mendocino, and Lake, and Trinity County were assumed to be similar to the Petaluma region. The Sierra counties of Plumas, Sierra, Nevada, Placer, Eldorado, Amador, Alpine, Calaveras, Tuolumne, Mariposa, Mono, and Inyo, and Imperial County were assumed similar to the Southern California region. The central coastal counties of Alameda, San Mateo, Santa Clara, Santa Cruz, San Benito and Monterey and the southern coastal counties of San Luis Obispo, Santa Barbara, and Ventura were assumed similar to the South Valley region.

Table 1. Consumption Regions, Counties Included, and Number Of Dairy Cows In Each, 1982

Region name (alfalfa market centers)	Counties included	Number of milk cows that have calved
Petaluma (Petaluma)	Sonoma	36,000
	Marin	13,000
	Contra Costa	2,500
	Napa	2,000
		53,500
North Valley (Escalon-Modesto-Turlock)	Sacramento	21,600
	San Joaquin	61,000
	Stanislaus	107,000
	Merced	90,000
	Madera	17,000
		296,600
South Valley (Tulare-Visalia-Hanford)	Fresno	54,700
	Tulare	115,000
	Kings	56,000
	Kern	20,000
		245,700
Southern California (Chino Valley)	Los Angeles	4,300
	San Bernardino	166,000
	Riverside	90,000
	San Diego	17,000
	Orange	300
		277,600
TOTAL:		873,400 (93% of state total of 940,000)

Source: California Crop and Livestock Reporting Service, *Livestock Statistics,* 1982.

P_m = blend price of milk, $/cwt

f( ) = milk production function

P_i = price of feed i, $/lb

q_i = quantity of feed i, lb/day.

This maximization is subject to various types of constraints including nutrient and maintenance requirements for cows of various body weights, production requirements at various levels of milk production and fat tests, maximum voluntary roughage intake as concentrate intake is increased, minimum fiber and roughage levels to maintain normal milk-fat tests, palatability restrictions and a segmented production function. Given the price of milk and feed and the nutrient content of the available feeds, the model is solved for the profit maximizing combination of feedmix that makes up the daily ration. Other factors affecting the optimum ration, such as the cow's daily production ability, weight and lactation stage, and average milk fat, are imposed on the model externally at predetermined levels.

Running the California Dairy Ration Program

The California Dairy Ration Program formulates the optimum feed intake on a daily basis. A cow's ability level is specified as pounds of milk per day. The program is restricted to a 30-100 pound range in 10-pound intervals. The prices of other feeds used in the model are given in Table 2. Types of feed available and

Table 2. Available Feeds and Prices in Each Region, 1982 Average Prices

Feed Number	Feed Name	Petaluma	North Valley	South Valley	Southern California
		— dollars per hunderweight —			
2	Almond hulls	3.15	3.19	3.19	3.15
7	Barley	6.45	6.50	6.50	6.40
9	Beet pulp, dried	6.18	6.27	6.27	6.15
15	Brewers grain, wet	1.59			
21	Corn grain	6.18			6.50
24	Cottonseed meal, 41E	7.95		7.86	7.60
25	Cottonseed meal, 41S	9.00	8.64		8.25
26	Cottonseed meal, 50S	7.00			
27	Cottonseed, whole	8.64	7.50	7.50	8.65
29	Dicalcium phosphate	15.66	18.00	15.66	19.00
36	Hominy feed, 5% fat		6.14	6.14	
37	Hominy feed, low fat				7.00
39	Limestone, ground	1.10	2.72		
42	Malt, barley	6.14			
46	Molasses, cane	6.36			
48	Monoammonium phosphate				29.00
50	Oats, lightweight	5.23			
51	Oats, Pcs	5.45			
52	Orange pulp, dried		5.90		
58	Rice bran	5.90	4.77		
68	Soybean meal	10.59			
74	Wheat, mill run	4.68	5.90		6.45
75	Wheat, soft				6.66
82	Alfalfa hay	3.00-10.00	3.00-10.00	3.00-10.00	3.00-10.00
89	Corn silage		1.50	1.50	
90	Cottonseed, hulls		2.95	2.95	2.00
93	Oat silage, boot	1.40	1.50	1.50	
94	Oat silage, dough	1.40	1.50	1.50	
Blend price of milk		13.07	12.88	12.96	13.24

Sources: U.S Department of Agriculture, Federal-State Market News Service, *Feedstuff Prices in California Monthly and Yearly Averages,* 1982.

Personal communication with feed suppliers, county dairy farm advisors and dairy farmers. See Appendix Table 1 for a detailed nutrition composition of each feed.

their prices vary from region to region. The feeds listed in Table 2 are available most of the time; their average 1982 prices are given.

A blend price of milk is calculated for each of the four regions as a weighted average of quota, base and overbase prices of milk. Quota, base, and overbase prices are determined statewide and depend on the shares of various grades and prices of milk that go into each. (For an explanation of this complex pricing scheme, see California Department of Food and Agriculture, 1982a, 1982b, 1981, 1974; Milligan, 1978; and Shanbazian, 1981.) These prices differ for each dairy farmer depending on location differentials and assigned milk quota levels. The blend price for a region is calculated as an average of the quota, base, and overbase prices from CCLRS, *Dairy Information Bulletin,* 1982, weighted by the aggregate quota, base and overbase milk in each respective region. These aggregate regional quota and base assignments are calculated from county assignments by the California Department of Food and Agriculture (1982c), which are aggregates of all milk producers' quota and base in a given county. The overbase is the difference between total milk output and the sum of quota and base. The resulting blend prices are given in the last row of Table 2.

A cow's output varies during lactation, with its highest level early in the period, then a steady decline thereafter. Table 3 shows the distribution of output, over a typical 10-month lactation, expressed as a percentage of total output. Dairy farmers, especially ones with large herds, generally separate their milking cows into several strings according to level of production or stage of lactation, and feed each group a different combination of roughage and concentrate that closely meets the nutritional needs of each string. This practice has been shown to be very cost-effective and dairy farmers are strongly urged to follow it (Pelissier and Bath., 1977, pp. 71-80; Bath, 1982; Pearson, 1979). A cow is moved from one string to another throughout a given lactation as her milk output and hence nutrition requirements change.

In this study, dairy farmers are assumed to feed their cows in four separate production strings, producing 40, 60, 80 and 100 pounds of milk a day, respectively. For instance, a typical cow that produces 16,000 pounds of milk in a 10-month lactation will be fed in the 80-pound producing string during the first three months of the lactation, in the 60-pound string for the next four months , and in the 40-pound string for the last three months.

Given the input prices and blend prices of milk, the model is solved for various prices of alfalfa for each production string. The alfalfa price is varied from $3 to $10 at $1 intervals. Alfalfa consumption is constrained to a minimum of 7 pounds per day in the first three regions and to 10 pounds per day in Southern California.[2] The minimum constraint is higher for Southern California because there are fewer substitutes for alfalfa there. There are several other predetermined specifications for the model, such as the average cow weight and milk fat, which are assumed to be the same for each region. (See Appendix Table 2 for these other specifications in a typical computer printout of the program.) The optimum daily alfalfa consumption in the four regions, for four production strings at various alfalfa prices is given in Table 4. Results show that at low prices more alfalfa is fed to the lower production strings than to the higher ones. High-producing cows need more energy than the low producers, but since the maximum voluntary intake is a constraining factor, the energy requirement of the high producers is initially met by specified levels of concentrates, supplemented by alfalfa; where as, low producers can obtain most or all of their energy needs from alfalfa alone if its price is sufficiently low.

Table 3. Monthly Milk Output as a Percentage of Total Output

Month	1	2	3	4	5	6	7	8	9	10
	Percent									
Percentage of total output	13.6	13.4	12.3	11.3	10.3	9.4	8.5	7.7	7.0	6.5

Source: Nyles Peterson, Dairy Farm Advisor, San Bernardino County.

REGIONAL ALFALFA CONSUMPTION BY MILK COWS

The results of the normative model are on a per cow per day basis. To obtain regional aggregate demand curves daily alfalfa consumption per cow must be converted to yearly consumption per cow and then aggregated over all cows in a given region. To accomplish this, three sources of information are needed. First, information on the distribution of cows among yearly production groups must be obtained.

[2]These constraints were imposed after consulting with dairy farm advisors (Bennett, Peterson).

Table 4. Optimum Daily Alfalfa Consumption Per Cow By Region, Alfalfa Price, and Level of Milk Production

Alfalfa price	Milk production (lbs/day)			
	40	60	80	100
dollars per hundredweight	— pounds of alfalfa —			
	Petaluma			
3	35.86	28.76	27.17	21.00
4	21.00	21.00	25.00	21.00
5	7.00	7.00	7.54	21.00
6	7.00	7.00	7.00	15.50
7	7.00	7.00	7.00	8.47
8	7.00	7.00	7.00	7.00
9	7.00	7.00	7.00	7.00
10	7.00	7.00	7.00	7.00
	North Vallley			
3	36.19	30.95	28.00	24.00
4	21.00	18.87	24.28	21.43
5	10.89	15.57	18.42	17.50
6	7.00	7.00	7.00	16.20
7	7.00	7.00	7.00	10.84
8	7.00	7.00	7.00	7.00
9	7.00	7.00	7.00	7.00
10	7.00	7.00	7.00	7.00
	South Vallley			
3	36.30	31.59	28.00	24.00
4	21.00	18.87	24.28	22.00
5	12.00	15.85	21.40	21.71
6	11.24	15.80	19.04	20.80
7	7.00	9.92	13.41	20.55
8	7.00	8.13	13.03	15.38
9	7.00	8.13	13.03	15.10
10	7.00	8.13	13.03	15.10
	Southern California			
3	36.92	30.90	27.73	23.83
4	25.76	29.48	24.87	21.00
5	14.27	16.97	20.16	20.39
6	10.00	10.00	13.97	17.93
7	10.00	10.00	11.72	17.70
8	10.00	10.00	11.72	16.08
9	10.00	10.00	11.72	15.05
10	10.00	10.00	11.72	14.83

Source: Calculated

Second, the distribution of the yearly milk output per cow within a given production group is needed for a typical ten-month lactation period. Third, the economic break-even point for cows in each production group must be determined. When the price of alfalfa increases, some categories of cows become unprofitable to keep and are culled.

Distribution of Cows Among Production Groups

The production data needed to calculate production group assignments are available on tapes at two data processing firms located in Tulare, California, and Provo, Utah. These firms provide computer services for the California Dairy Herd Improvement Association (DHIA), a joint venture sponsored by California dairy farmers, UC Cooperative Extension Service, and the Dairy Cattle Research Branch of the U.S. Department of Agriculture. Dairy farmers, through their local, state and national DHIA organizations, are responsible for the conduct of the program in compliance with established policies, rules and standards. The members of this voluntary association send detailed information on most of their cows to one of these two firms including the production and feed ration data discussed above. The information further includes such things as the cow's age, physical traits, lactation stage, monthly and complete lactation milk output and fat content of the milk. The two data firms compile this information and provide it to dairy industry concerns. It becomes part of the national data base, aiding research on herd management and genetic improvements, benefiting the entire dairy industry in the long run.

Data on computer tapes from the Animal Science extension, UC Davis, show that some cows milk well beyond the desired 305 day lactation and some go dry sooner than 305 days. Thus, a cow's output depends not only on her ability to produce but also on the length of the lactation. To assign the cows into production groups, each cow's total output is adjusted to 305 days by using adjustment formulas and factors obtained from Thompson. The resulting 305-day production is then grouped into production categories at 1000-pound intervals.

A further adjustment needs to be made to the production group assignments before they can be generalized regionally. Dairy farmers who are members of DHIA tend to be more efficient operators with greater average milk output than non-DHIA dairymen. Given the total milk output and number of dairy cows in DHIA member farms in the demand regions, average output per DHIA cow is calculated and compared with the residual output and cow numbers assumed to be non-DHIA. Results show that the average output per DHIA cows is 2,000 pounds greater than for a non-DHIA cow in Petaluma, 1,00 pounds greater in North Valley and in Southern California; there is no appreciable difference in the South Valley region.

The regional distributions including total cows in taking the weighted average of DHIA and non-DHIA distributions, where non-DHIA distributions are assumed to have the same shape as DHIA distributions but a different mean. The weights used are the percentage of cows in DHIA and non-DHIA farms. Results are given in Table. 5.

Distribution of Output per Cow over a Ten-Month Period

Given the production groups in Table 5, the expected monthly ouput for each group is calculated by applying the percentages in Table 3. To make the monthly output levels adaptable to the normative model, output is divided by 30.5 for the average daily output for a given cow in a given month. Results range from 21 pounds of milk per day in the tenth month for a 10,000-pound producer to 133 pounds of milk per day in the first month for a 30,000-pound producer.

Recall that dairy farmers are assumed to separate their cows into four production strings each of which is fed a different ration. Those with averge daily output between 0-40 pounds are assumed to be fed in a 40 pound string; 41-60 pound producers in a 60 pound string; 61-80 pound producers in a 80 pound string; and 81 pounds or more in a 100 pound string. Table 6 shows the total number of months a given production group is fed in a given feeding string.

Yearly alfalfa consumption by each production group is calculated from Tables 4 and 6, using 30.5 to convert daily consumption in Table 4 to monthly consumption. Recall that cows are assumed to be fed the same ration during their two dry months as at the end of their lactation. Annual alfalfa consumption by production group is then aggregated using the data in Table 5 to determine regional quantities demanded for various prices of alfalfa.

Break Even Point

Before the calculated price-quantity combinations can be used to estimate demand curves, adjustments in aggregate quantities consumed must be made for cows culled as the price of alfalfa increases. Currently a dairy cow producing 16,000 pounds in her second or later lactations is considered a marginal cow: Any cow producing less is culled. The rationality of this management practice can be checked by calculating yearly profit per cow for the 15,000-17,000 pound categories.

The yearly profit per cow is calculated as the difference between total revenue and total variable cost. The feed portion of the variable cost is obtained from the Dairy Ration Program results (see Appendix Table 2). Added to that are other variable costs such as labor and variable operating expenses per cow (California Department of Food and Agriculture, 1982d). Table 7 shows the yearly net revenues for the three production groups at various prices of alfalfa.

At an alfalfa price of $5 per hundred weight (cwt), the 15,000 pound category is unprofitable to keep. Net

Table 5. Distribution of Cows By Level of Milk Production and By Region

Milk output per 305 day lactation (pounds)	Petaluma		North Valley		South Valley		Southern California	
	percent of total	number of cows	percent of total	number of cows	percent of total	number of cows	percent of total	number of cows
10,000 or less	7.30	3904	7.32	21719	5.76	14152	2.82	7840
11,000	5.11	2734	5.24	15529	3.37	8280	2.94	8162
12,000	6.54	3501	6.69	19846	4.96	12187	4.47	12412
13,000	7.95	4251	8.26	24505	7.06	17346	6.47	17958
14,000	8.57	4587	8.88	26329	8.85	21744	8.61	23895
15,000	9.57	5122	9.63	28568	10.12	24865	10.24	28423
16,000	9.96	5326	9.85	29228	10.73	26364	11.27	31289
17,000	9.50	5083	9.44	27987	10.48	25749	11.30	31357
18,000	8.73	4671	8.52	25283	9.62	23636	10.44	28991
19,000	7.67	4104	7.20	21350	8.05	19779	9.07	25188
20,000	6.01	3218	5.77	17108	6.54	16069	7.36	20428
21,000	4.60	2460	4.40	13053	4.92	12088	5.46	15152
22,000	3.29	1758	3.16	9363	3.60	8845	3.88	10776
23,000	2.10	1125	2.20	6514	2.33	5723	2.50	6953
24,000	1.37	735	1.43	4227	1.48	3636	1.46	4064
25,000	.79	421	.89	2634	.91	2236	.85	2305
26,000	.46	247	.51	1525	.58	1425	.45	1251
27,000	.25	132	.29	862	.29	713	.20	548
28,000	.13	69	.16	475	.16	393	.09	254
29,000	.06	33	.10	297	.09	221	.08	210
30,000 or more	.04	24	.07	199	.10	246	.03	96
TOTALS	100.00	53,500	100.00	296,600	100.00	245,700	100.00	277,600
Percentage of cows that are in DHIA	(76)		(67)		(57)		(43)	

Source: See text

Table 6. Number of Months Cows are Fed in a Production String, Depending on Milk Output

Milk output per 305 day lactation (pounds)	Feeding strings by daily output of milk (lbs/day) 40	60	80	100
	Months			
10,000 or less	10	2	—	—
11,000	9	3	—	—
12,000	8	4	—	—
13,000	7	5	—	—
14,000	6	6	—	—
15,000	5	5	2	—
16,000	5	4	3	—
17,000	4	4	4	—
18,000	4	3	5	—
19,000	4	3	3	2
20,000	—	6	4	2
21,000	—	6	3	3
22,000	—	5	4	3
23,000	—	5	3	4
24,000	—	4	4	4
25,000	—	4	3	5
26,000	—	4	3	5
27,000	—	3	3	6
28,000	—	3	3	6
29,000	—	—	6	6
30,000	—	—	5	7

Sources: See text

Table 7. Net Revenue Per Cow Per Year for 15,000-17,000 Pound Producing Cows, by Region

Alfalfa price	Pound of Milk Production 15,000	16,000	17,000
dollars per hundredweight		— dollars of —	
		Petaluma	
3	101.42	231.42	344.43
4	46.52	176.52	288.30
5	- 81.50	48.42	158.98
6	-107.21	22.80	133.36
7	-132.83	- 2.83	107.74
8	-158.45	- 28.45	82.12
9	-184.07	- 54.07	50.50
10	-209.69	- 79.79	30.88
		North Vallley	
3	134.64	263.64	367.32
4	13.86	142.86	255.08
5	- 61.79	67.22	175.78
6	-107.23	21.77	125.76
7	-132.85	- 3.85	100.14
8	-158.47	- 29.47	74.52
9	-184.09	- 55.09	48.90
10	-209.71	- 80.71	23.28
		South Vallley	
3	161.28	291.28	394.96
4	41.72	171.72	283.94
5	- 33.93	96.08	204.64
6	- 70.26	59.48	161.94
7	-118.41	11.59	111.92
8	-153.18	- 28.18	75.32
9	-185.51	- 55.51	41.16
10	-217.84	- 87.84	7.00
		Southern California	
3	38.88	170.88	280.70
4	11.43	143.43	251.42
5	- 59.94	72.06	178.22
6	-106.00	26.01	130.64
7	-134.36	- 2.36	105.02
8	-172.79	- 40.79	65.98
9	-203.90	- 71.90	34.26
10	-241.42	-109.42	- 3.45

Regional milk prices are those used in the normative model.

Source: Calculated

revenue for the 16,000 pound category becomes negative with an alfalfa price of \$7/cwt. For the 17,000 pound category, net revenue is positive except in Southern California with alfalfa at \$10/cwt. The results in Table 7 are consistent with the current practice of culling the 15,000-pound milk producers and treating the 16,000-pound category as marginal. Table 7 does not show the final break-even point, since a fixed blend price of milk is used in calculating the net revenues. California law governing the dairy industry requires bimonthly adjustments in the price of market milk with changes in the cost of production. When an upward adjustment is made, some of the negative profits shown would be offset by an increased blend price.

Increases in the cost of production lead to an increase in the minimum price of Class 1 milk via an automatic formula. (See California Department of Food and Agriculture, 1982e, p.5.) The ingredients of this formula are the Class 4 price, the cost of milk production, and the average weekly earnings for manufacturing production workers. An increase in the Class 1 price then increases the quota price, which in turn increases the blend price. Class 1 milk makes up about 75 percent of the quota milk, and the quota's share in the blend price is around 60 percent.

Net revenues are then recalculated to reflect the change in blend price, given the increases in the cost of production. Results show that losses are offset up to an alfalfa price of \$8/cwt for Petaluma, South Valley, and Southern California, and up to \$9/cwt for North Valley. The 15,000 pound category is unprofitable at any alfalfa prices above \$5/cwt, while the 17,000 pound category generates profits at all prices. The break-even price of alfalfa for the 16,000 pound category and the expected reduction in the number of cows in each region are given in Table 8. It is possible that, as low producers are culled, there will be genetic improvement in a herd. This would increase the mean of the regional distributions which, in turn, would affect the aggregate alfalfa consumption. However, in the short run, the improvement in average milk output is negligible; including it in the calculations would unduly complicate the analysis.

Percentages used to calculate the number of cows culled is the difference between the percentage of cows in the 16,000 pound group (see Table 5) and the percentage of 16,000 pound producers in their first lactation (see Appendix Table 3). Cows are not usually culled until after this first lactation, when they reach maturity. The aggregate optimum alfalfa consumption is adjusted downward for the quantity that would have been consumed by culled cows. The resulting price-quantity combinations, converted to tons, are given in Table 9.

The fifth column of Table 9 gives alfalfa demand by milk cows not included in the four regions. Since the number of these milk cows is small (7 percent of all milk cows in the state), no attempt was made to estimate separate alfalfa demand relations for them. They are grouped under "other"; demand is estimated using the results from the major consumption region closest to each particular county or subregion (for details see the description of the consumption regions in Section II).

REGIONAL ALFALFA DEMAND BY MILK COWS

The data in Table 9 are fitted using ordinary least squares to a log-linear demand function with the following form:

$$Q = aP^b$$

where:

P is the price of alfalfa

Q is the quantity consumed

a, b are parameters

Several other functional forms were estimated (e.g., linear and quadratic) but the log-linear form gave the best results statistically. Parameter estimates and summary statistics are given in Table 10. Demand for alfalfa is apparently less elastic in the southern regions—an outcome not unexpected since there are fewer substitutes for alfalfa there.

Table 8. Break-even Price of Alfalfa for 16,000 Pound Milk Producers and Number of Cows Culled

Regions	Break-even price of alfalfa	Number of cows culled	Number of cows culled as a percentage of the total
	dollars per cwt	number	percent
Petaluma	8	3,602	6.73
North Valley	9	18,629	6.28
South Valley	8	16,776	6.83
Southern California	8	19,893	7.17

Source: Calculated

Table 9. Aggregate Annual Alfalfa Consumption by Milk Cows by Price of Alfalfa and Region

Alfalfa Price	Petaluma	North Valley	South Valley	Southern California	Other	Total
$/ton			tons			
66	301,813	1,742,008	1,443,616	1,615,981	387198	5490616
88	212,970	1,132,941	942,663	1,350,496	259259	3898329
110	77,981	777,467	716,312	861,713	162796	2596269
132	73,678	410,687	678,632	580,333	126726	1870056
154	69,428	392,776	461,145	554,826	102287	1580462
176	63,925	379,945	384,897	509,611	91708	1430086
198	63,925	356,081	384,102	506,243	89703	1400054
220	63,925	356,081	384,102	505,401	89698	1399207

Source: Calculated

Table 10. Estimated Alfalfa Demand by Milk Cows, by Region

Region	Constant ln a	Price Coefficient b	R^2
Petaluma	18.009 (1.283)	-1.338 (0.261)	.81
North Valley	20.202 (0.885)	-1.419 (0.180)	.91
South Valley	18.978 (0.453)	-1.159 (0.092)	.96
Southern California	18.807 (0.681)	-1.085 (0.139)	.91
Other	18.172 (0.592)	-1.291 (0.121)	.95
Total	20.585 (0.568)	-1.227 (0.116)	.95

Standard errors are in parentheses. All estimated coefficients are significant at the 1 percent level.

Sources: Estimated from data in Table 9.

III. ESTIMATES OF ALFALFA FED TO NON-MILK LIVESTOCK AND THE AGGREGATE NORMATIVE DEMAND FUNCTION

In this section alfalfa demand by non-milk dairy and non-dairy livestock are estimated on a per-animal basis and then are aggregated over all respective animals in 25 regions.

Calculations made here show that in 1982, 41 percent of total alfalfa consumption in California is by milk cows, 18 percent by non-milk dairy animals, 17 percent by beef cattle, and 24 percent by horses. Alfalfa consumption demand by animals other than milk cows is assumed to have zero elasticity for several reasons. For beef cattle the share of alfalfa in the daily ration is small compared to other feeds. It is mostly used to supplement pasturage, usually through the winter when grazing is not available, or in emergencies when natural feed is late or less than expected. Therefore a change in consumption by beef cattle is not likely to affect aggregate alfalfa consumption substantially.[3] Alfalfa provides energy more efficiently than other feeds, especially for growing calves and heifers and to a certain extent for fattening cattle in the feedlots. Therefore, a change in the price of alfalfa is expected to bring about a relatively small change in the amount fed per animal.

Alfalfa is a preferred horse feed because of its high nutritional value and palatability, so horseowners are expected to show a very small response to changes in alfalfa price.

Alfalfa is an important part of the non-milk (replacement heifers, calves, and bulls) dairy livestock ration. It is needed for its rich nutrient content in aiding the healthy growth of young animals. Young cattle and calves are grazed on pasture and fed other forages as available; alfalfa supplements these other feeds. Therefore, dairy farmers are not expected to greatly alter the amount of alfalfa in the rations of non-milk dairy cattle with changes in the alfalfa price. Historical and regional data on alfalfa consumption by non-milk livestock are not available, but it seems reasonable to assume in the short run that alfalfa demand by these animals stays constant as the price changes.

First, alfalfa consumption per head by animals other than milk cows is discussed. Then, regional cattle and horse numbers are estimated, and their aggregate alfalfa consumption is calculated.

ALFALFA CONSUMPTION PER HEAD

Dairy Cattle

The regional quantity of alfalfa consumed per milk cow at the 1982 average alfalfa price is calculated from the demand equations in Table 10 and is given in Table 11. The source for other (statewide) estimates in Table 11 is King et al., 1980.

Beef Cattle

The three main stages in raising beef cattle for slaughter are breeding herd to wearner calf, stocker (weaner calf to yearling feeder), and feedlot finishing. These three stages take approximately 19 to 24 months; feed requirements change throughout the process. In the first stage the newborn calf is kept with the mother for up to 8 months where it is sustained with her milk and by grazing on pasture. After reaching 400-500 pounds it is weaned and considered a yearling. Some of these calves are kept as replacements and remain on grazing; the rest become stocker cattle and are fed a high forage ration of pasture and hay. According to Dunbar, two-thirds of this hay is alfalfa. This second stage lasts about 5 months when yearlings weigh as much as 700 pounds. The amount of alfalfa consumed at this stage is estimated to be .18 ton per year per animal and is reported under lightweight calves fed in Table 11. (Most of the yearlings are under 1 year of age and thus are still considered calves.) The third stage of beef production is performed in a feedlot where the ration is based largely on concentrates. The purpose is to fatten feeder cattle to a grade of Good or Choice beef to meet market demand, but they are also fed hay for proper digestion. Cattle can stay in the feedlot from 2-5 months and sometimes longer, depending on weight at arrival, daily weight gain and desired weight gain. On average, feedlot cattle consume .2 ton of alfalfa hay per year. Alfalfa consumption by the remaining beef cattle is given in Table 11.

Horses

The amount and type of feed a horse needs varies according to its weight and the work it performs. Like cows, horses require energy, protein and vitamins for maintenance, growth, work and reproduction. Many different feeds can supply the necessary nutrients for horses, but alfalfa is the most nutritious of hays available in California. It can make up all or part of a ration, and it is the most common roughage fed to horses in the state. There is no reliable estimate of

[3]While there are computer programs for formulating beef rations, they are not used uniformly and are not as accessible as the California Dairy Ration Program.

Table 11. Estimated Annual Quantity Fed Per Head, Milk Cows, 1982, and Other Livestock, 1974-1976

	Feed grains	Other concentrates	Hay	Pasture[a]	Alfalfa hay[b]	Share of alfalfa in total ration
Dairy	— — — —	— — — —	tons	— — — —	— — — —	percent
Milk cows						
Petaluma					2.33	
North Valley					2.47	
South Valley					3.51	
So. California					3.75	
Heifers	0.190	0.367	2.665	2.24	2.532	46
Calves	0.196	0.367	0.45	2.24	0.428	13
Bulls	—[c]	—	4.5	2.24	4.275	63
Beef						
Cows	0.013	0.045	1.00	4.65	0.67	12
Heifers and bulls	—	—	0.70	2.24	0.47	10
Lightweight calves fed	0.215	0.115	0.27	—	0.18	20
Feedlot finishing	1.12	0.48	0.30	—	0.20	11

[a]The estimates of pasture consumption are reported in Animal Unit Months (AUM) in the above source and are converted into tons, multiplying by .4 ton/AUM.

[b]King et al. do not distinguish between alfalfa and other hay types in their estimates of hay fed per head. Estimates for alfalfa are derived by assuming that the share of alfalfa in total hay consumption is 95 percent for dairy and 67 percent for beef livestock.

[c]Dashes indicate not applicable.

Source: Estimates for milk cows are calculated from the demand equations in Table 10 assuming an avergage 1982 alfalfa price of $113.03 in Petaluma, $114.02 in North Valley, $99.03 in South Valley, and $98.75 in Southern California. Estimates for non-milk livestock are calculated from King et al., *Trends in California Livestock and Poultry Production, Consumption, and Feed Use: 1961-1978,* Tables 6 and 7.

horses, but alfalfa is the most nutritious of hays available in Califonria. It can make up all or part of a ration, and it is the most common roughage fed to horses in the state. There is no reliable estimate of alfalfa consumption per horse; however, various studies suggest amounts of 5-15 pounds per 1,000 pound horse at medium work (Albaugh et al., 1983; Baer, 1982). Another difficulty involves the total number of horses reported statewide. Specifically, the various estimates show large discrepancies. In the light of these uncertainties total statewide alfalfa consumption by horses is taken to be the difference between available supply of alfalfa and the estimated consumption by all other livestock net of horses. Aggregate alfalfa consumption by all dairy and beef cattle is estimated; the resulting quantity is subtracted from available supply (including net imports) to arrive at total consumption by horses. The regional consumption by horses then depends on the number of horses in each region. Even though regional horse numbers may not be precise, they are nevertheless expected to reflect the relative shares of the horse population among the regions.

LIVESTOCK NUMBERS

Livestock numbers are estimated for 25 regions in California. All types of cattle and horses are considered in order to estimate the regional breakdown. Consumption by milk cows is then netted out to determine alfalfa consumption by non-milk livestock.

Dairy Cattle

The available data provide county-level numbers of milk cows, but only statewide numbers for the rest of the dairy livestock. The CCLRS, California Livestock Statistics gives Statewide data for heifers, calves, bulls, and steers. Expressing these aggregates as percentages of milk cows in each county could give county-level estimates for the remaining categories of dairy animals. But CCLRS in 1982 reports dairy calves, bulls, and steers together with the same categories for beef. Earlier livestock reports (1955 to 1970), however, separate the data by dairy and beef. Thus, the average of the historical allocation between beef and dairy was used to separate them in 1982. About 75 percent of the dairy farmers in Riverside and San Bernardino counties send their weaned female calves to other parts of the state (two-thirds) or out of state (one-third) to be raised on pasture until they are ready to give birth to their first calf. Smaller percentages are used for heifer and calf numbers in these two regions to account for the outshipments. The resulting estimates are given in Table 12.

Beef Cattle

Basically the same procedure is used to derive regional beef heifer, calf and bull numbers as was used for dairy cattle. However, estimating regional numbers for beef steers requires some additional calculations. Steers are castrated males more than 1 year old and over 500 pounds. Most of them are either in feedlots (73 percent in 1982) or destined for feedlots to be fattened for market. They are not, therefore, equally allocated among regions in proportion to beef cow population since feedlots tend to be concentrated in certain areas of the state. Availablility, price of feed grains, and to some extent the weather determine feedlot location. Most are located in Southern California and the San Joaquin Valley. To derive the regional beef steer numbers, all dairy and beef cattle categories estimated to this point are summed for each region and the results are subtracted from the regional "all cattle and calves" figures in CCLRS Livestock Statistics to yield an estimate for beef steer and feedlot cattle. For those regions without feedlot operations, the net figures are negative because they included steer calves sold to feedlots right after weaning. Since individual cattle categories have to add up to the all cattle and calves total for each region, negative amounts were forced to zero by subtracting them from the "beef calves" number. The estimated regional beef steer numbers correspond closely with the more aggregate regional feedlot cattle numbers reported in CCLRS. The final figures are in Table 12.

Horses

Estimates of the California horse population vary widely. One estimate by Collins (1978) reported 900,000 horses for 1975. A 1978 estimate by the U.S. Department of Commerce gave the California horse population as 112,000, while an American Horse Council estimate for 1980 was 843,000. The California State Horsemen's Association provides county estimates for 1980 that total 1,040,000. In this study estimates of the regional shares of the horse population rather than absolute numbers will have to suffice. Precise numbers would not be that much help anyway because of the uncertainty about alfalfa consumed per horse. County estimates by the California State Horsemen's Association are used for this study. Table 12 gives the estimated regional horse numbers.

Table 12. Regional Livestock Numbers, 1982

County or region No.	All cattle and calves	Milk cows	Dairy heifers	Dairy calves (heifers, bulls, steers)	Dairy bulls and steers	Beef cows	Beef heifers	Beef calves (heifers, bulls, steers)	Beef bulls	Beef steer and feedlot cattle	Horses
Petaluma											
1. Petaluma[a]	202000	53500	26446	17844	1252	53500	9685	36499	3275	0	37570
North Valley											
2. Sacramento	125000	21600	10677	7204	506	37000	6698	39050	2265	0	50404
3. San Joaquin	215000	61000	30152	20346	1428	46000	8328	44931	2816	0	34428
4. Stanislaus	315000	107000	52891	35688	2504	42000	7603	56150	2571	8593	22952
5. Merced	350000	90000	44488	30018	2106	68000	12310	90909	4162	8007	22952
6. Madera	130000	17000	8403	5670	398	31000	5612	41444	1897	18576	9181
South Valley											
7. Fresno	372000	54700	27039	18244	1280	53000	9595	70856	3244	134043	39018
8. Tulare	325000	115000	56846	38356	2691	34000	6155	45455	2081	24416	12898
9. Kings	128000	56000	27681	18678	1311	6000	1086	8021	367	8855	5738
10. Kern	240000	20000	9886	6671	468	61000	11043	81551	3734	45648	29837
Southern California											
11. Los Angeles	42000	4300	2126	1434	101	5000	905	6684	306	21144	150334
12. San Bernardino	280000	166000	56374	41040	3885	7000	1267	4005	428	0	58527
13. Riverside	190000	90000	30519	20824	2106	9000	1629	12032	551	23338	82626
14. San Diego	57000	17000	8403	5670	398	9000	1629	12032	551	2317	35690
15. Orange	14000	300	148	100	7	3500	634	4679	214	4418	24523
Other											
16. Mountain[b]	314000	3850	1903	1284	90	182000	32948	80785	11140	0	58759
17. North Coast[c]	128000	16950	8379	5653	397	57000	10319	25813	3489	0	44725
18. Trinity	7000	0	0	0	0	3000	543	3273	184	0	3835
19. Yuba	38000	1700	840	567	40	16000	2897	14977	979	0	10646
20. Sacto. Valley[d]	255000	20900	10331	6971	489	106000	19190	84631	6488	0	63153
21. Solano	47000	1100	544	367	26	15000	2716	20053	918	6277	3958
22. Sierra[e]	192000	1250	618	417	29	104000	18828	60493	6366	0	98394
23. Central Coast[f]	328000	10150	5017	3385	238	102500	18556	137032	6274	44848	78862
24. South Coast[g]	256000	10300	5091	3435	241	106500	19280	104633	6519	0	55017
25. Imperial	450000	400	198	133	9	3000	543	4011	184	441522	6886
State Totals:	5,000,000	940,000	425,000	290,000	22,000	1,160,000	210,000	1,090,000	71,000	792,000	1,040,913

[a]Sonoma, Marin, Contra Costa, Napa counties
[b]Siskiyou, Modoc, Shasta, Lassen counties
[c]Del Norte, Humbolt, Mendocino, Lake counties
[d]Tehema, Glenn, Butte, Colusa, Sutter, Yolo counties
[e]Plumas, Sierra, Nevada, Placer, El Dorado, Amador, Alpine, Calaveras, Tuolumne, Mariposa, Mono, Inyo counties
[f]Alameda, San Mateo, Santa Clara, Santa Cruz, San Benito, Monterey counties
[g]San Luis Obispo, Santa Barbara, Ventura counties

Sources: Calculated using CCLRS, *California Livestock Statistics* and *California Dairy Industry Statistics,* various issues.

TOTAL ALFALFA CONSUMPTION BY REGION

Tables 11 and 12 contain the necessary information to calculate the regional aggregate alfalfa consumption by dairy and beef cattle. Per-head consumption figures for milk cows in Table 11 are used to estimate the aggregate alfalfa consumption by milk cows in the four major dairy regions. For the remaining regions alfalfa consumption per milk cow is assumed to be the same as that in the closest major consumption region as discussed in Section II. Dairy steers (missing in Table 11) are assumed to consume the same amount of alfalfa as dairy bulls. These steers number only 8,000 statewide so this assumption is not critical. No estimate for per head alfalfa consumption by beef steers is given in Table 11. Twenty-seven percent of the "Steers and Bulls" category in Table 12 are steers that are not yet in feedlots. Lacking data to accurately estimate their consumption, they are assumed to consume the same amount of alfalfa as feedlot cattle. This may result in a slight underestimation of alfalfa consumption because an animal's ration outside a feedlot tends to contain more roughage and hence more alfalfa than a feedlot ration.

The alfalfa supply in 1982 was 7,362,159 tons. This includes production of 6,863,387 tons plus 381,772 tons of net imports. Subtracting the aggregate alfalfa consumption by dairy and beef cattle (column 2 plus column 3 in Table 3) from the total supply gives statewide consumption by horses. (This also includes a very small amount consumed by sheep.) Dividing total alfalfa consumed by horses by the estimated horse population gives 1.67 tons per year of 9.15 pounds of alfalfa per day per horse. This estimate is within the range of 5-15 pounds per day estimated by Albaugh et al. (1983) and Baer (1982). The regional aggregate alfalfa consumption estimates are given in Table 13.

AGGREGATE NORMATIVE DEMAND FUNCTION

Estimated alfalfa demand by milk cows was given in Table 10. Table 13 gives estimated alfalfa consumption by all livestock in 1982 in each of 25 regions. Summing the totals of columns 1, 3 and 4 gives estimated alfalfa consumption by all non-milk livestock. This value is 4.295 million tons and is assumed to be invariant with respect to alfalfa prices for the reasons given earlier. Using the estimated equation in Table 10 for all milk cows, taking antilogs, and adding 4.295 for all other livestock, yields the normative demand function for alfalfa consumption in California:

$$Q = 870.9\ P^{-1.227} + 4.295$$

where Q is total alfalfa consumption in California (million tons) and P is the price of alfalfa in 1982 dollars ($/ton). The own-price elasticity of alfalfa demand is -.49 when evaluated at an average price paid by dairy farmers in 1982 of $104.88/ton.

Table 13. Regional Annual Alfalfa Consumption By Livestock Type

Consumption region	No.	County or region[a]	Dairy (except milk cows)	All dairy	All beef	Horses	Total
			— — — — — — — —		tons	— — — — — — — —	
Petaluma	1.	Petaluma	79950	204712	48506	62683	315901
North Valley	2.	Sacramento	32279	85631	36032	84097	205759
	3.	San Joaquin	91158	241828	44145	57440	343413
	4.	Stanislaus	159900	424190	44747	38294	507251
	5.	Merced	134495	356795	71267	38294	466356
	6.	Madera	25405	67395	35474	15317	118187
South Valley	7.	Fresno	81743	273740	81107	65099	419946
	8.	Tulare	171855	575505	39716	21519	636740
	9.	Kings	83688	280246	7918	9573	297738
	10.	Kern	29888	100088	71624	49782	221493
Southern California	11.	Los Angeles	6426	22551	9351	250824	282726
	12.	San Bernardino	176913	799413	6208	97649	903270
	13.	Riverside	95192	432692	13888	137857	584437
	14.	San Diego	25405	89155	9684	59547	158385
	15.	Orange	448	1573	4469	40915	46957
Other	16.	Mountain	5753	19267	157203	98036	274505
	17.	North Coast	25330	64857	49326	74621	188804
	18.	Trinity	0	0	2941	6399	9340
	19.	Yuba	2540	6739	15238	17763	39739
	20.	Sacramento Valley	31233	82856	98322	105367	286545
	21.	Solano	1644	4361	16623	6604	27587
	22.	Sierra Mountain	1867	6555	92409	164165	263130
	23.	Central Coast	15168	50795	113980	131577	296352
	24.	South Coast	15392	51545	102314	91792	245651
	25.	Imperial	598	2098	91378	11488	104964
State Totals:			1,294,268	4,244,587	1,263,870	1,736,700	7,245,159

[a]For regional breakdowns by county see footnotes in Table 12.

Sources: Estimated as explained in the text.

IV. ECONOMETRIC ESTIMATES OF ALFALFA DEMAND IN CALIFORNIA

This section provides econometric estimates of alfalfa demand in California. Alfalfa production data are available on a countywide basis from agricultural commissioner reports. The Federal-State Marketing News Service (MNS) provides price data for the major dairy livestock producing regions. However, no data on consumption of alfalfa are available by county or region. Therefore, econometrically estimated demand schedules for alfalfa can only be provided for the state as a whole.

REGRESSION MODELS

The quantity of alfalfa demanded in a given year is determined by the price of alfalfa, the price of other feeds, the price of various livestock products, and the number and type of livestock animals. Four different regression models are used in estimating statewide alfalfa demand. The following variables are used in each:

$CONS_t$ = alfalfa consumption in California, year t (1000 tons/year);

$PALF_t$ = price of alfalfa hay, year t ($/ton);

$PFEED_t$ = cost index for other feeds used in livestock production, year t;

$LPINDX_t$ = price index for livestock products, year t;

CAT_t = number of beef and dairy cattle, year t (1000 head).

The first demand function is specified as an aggregate linear relation between alfalfa consumption and the other variables plus a trend. Linear I:

$$(1) \qquad CONS_t = a_0 + {}_1\, PALF_t + a_2\, PFEED_t + a_3\, LPINDX_t + a_4\, CAT_t + a_5 t + a_6 t^2 + e_t$$

Time series data are not available for livestock other than beef and dairy cattle. The intercept and time trends in (1) allow for changes in consumption of these other animals over time as well as changes in feeding practices for dairy and beef cattle unrelated to prices.

Next we allow for the separate effects of changes in consumption per head and in numbers of cattle. Multiplying per head consumption by the number of head gives consumption by each livestock type and summing gives total consumption:

$$(2) \qquad CONS_t = Q_t^c \bullet CAT_t + Q_t^h \bullet HORS_t$$

where Q_t^c denotes per head consumption of dairy and beef cattle, Q_t^h denotes per head consumption by horses and other non-cattle livestock, and $HORS_t$ denotes numbers of horses and other non-cattle livestock. As noted previously, time series data on horses are unavailable so we assume

$$(3) \qquad HORS_t = b_0 + b_1 t$$

and similarly,

$$(4) \qquad Q_t^h = b_2 + b_3 t$$

The quantity of alfalfa consumed per head of cattle depends on the price of alfalfa, other feeds, and livestock products. A time trend may also be appropriate to account for technical change. Three different functional forms were used to specify per head cattle consumption:

Linear:

$$(5) \qquad Q_t^c = c_0 + c_1\, PALF_t + c_2\, PFEED_t + c_3\, LPINDX_t + c_4 t$$

Deflated linear:

$$(6) \quad Q_t^c = c_0 + c_1 \frac{PALF_t}{LPINDX_t} + c_2 \frac{PFEED_t}{LPINDX_t} + c_3 t$$

Generalized Leontief:

$$(7) \quad Q_t^c = c_0 + c_1 \left(\frac{LPINDX_t}{PALF_t} \right)^{1/2} + c_2 \left(\frac{PFEED_t}{PALF_t} \right)^{1/2} + c_3 t$$

Substituting (3) and (4) and one of (5)-(7) into (2) results in three alfalfa demand regressions to be estimated. It is easily confirmed that these regressions are linear in the parameters for all three functional forms. These demand functions are referred to as Linear II, Deflated Linear, and generalized Leontief, respectively.

Holding other variables constant, we expect quantity demanded to be inversely related to the price of alfalfa and positively related to livestock numbers and prices. The effect of a change in the price of other feeds is indeterminate: An increase will tend to increase alfalfa consumption through the substitution effect but will tend to decrease alfalfa consumption to the extent that milk or beef output per cow is lowered.

Time series data are available for beef and dairy cattle separately so (2) was also estimated by splitting the CAT_t variable into dairy and beef cattle numbers and specifying per head consumption for each using one of the three functional forms in (5)-(7). The results, however, were unsatisfactory and are not reported here.

DATA

The regressions were estimated using data from 1945-1982. The data sources are given in the references. As described below, some additional calculations were performed before estimation.

The cattle numbers used here are for all cattle and calves in California. The reported data are as of January 1. Since alfalfa is consumed throughout the year, we also used a time series for average number of cattle and calves during the year. This series was obtained by averaging the January 1 data. The livestock price index ($LPINDX_t$) was calculated as the weighted average of milk and beef prices with weights of .7 and .3, respectively. These weights represent the typical share of dairy and beef in alfalfa consumption. Milk and beef prices are both measured in dollars per hundred weight.

Alfalfa consumption ($CONS_t$) is calculated as alfalfa production plus carryin stocks and imports of alfalfa products to California minus carryout stocks and exports from California. Alfalfa represents by far the largest share of hay produced in the state. The CCLRS reports data for both total hay and alfalfa hay. While alfalfa hay production is used in estimating alfalfa hay consumption, total hay production is used in estimating alfalfa hay stocks. The data for hay stocks are stocks of all hay on farms, January 1 and May 1. Alfalfa hay stocks were estimated from this series by assuming that alfalfa stocks were the same fraction of total stocks as alfalfa production was of total hay production in the preceding year. Both January 1 and May 1 stocks data were used in the regressions.

Data on imports and exports of alfalfa products are problematical. There are no such data before 1962 (Lehigh, 1985). A considerable portion of alfalfa imports to California comes from Arizona; however, import data do not include shipments from Arizona between 1973-81 and part of 1982 when the border agricultural inspection stations were closed. Cube imports are also significant; however, data are available only for 1980-83 and only 1983 includes all shipments from Arizona. Inshipments of alfalfa typically represent a small portion of the overall supply (Cothern, 1982, suggests from 2 to 4 percent). Cothern also indicates that inshipments are not likely to increase much due in part to substantial transport costs. Because alfalfa imports and exports from California apparently represent a small part of the market and because of the severe data limitations, the main regression results reported here do not include trade data. We did, however, attempt to construct a time series for import/export data and reestimate the regressions. The results were generally poor and are not reported here.

Alfalfa price data are available directly for the years 1945-78. For the remaining years price was estimated by dividing the value of alfalfa production by the quantity produced. The price index for other feeds used in livestock production ($PFEED_t$) was estimated as a weighted average of the prices for barley, corn, and oats where the weights are the total quantities produced in California in each year. Two other feed cost indices are provided by the U. S. Department of Agriculture in its *Agricultural Statistics:* a feed cost index and a dairy feed cost index,[4] both for the United States. However, the correlation coefficients of these two indices with the constructed feed cost index are .97 and .96, respectively, precluding their joint use in least squares regressions.

REGRESSION RESULTS

There are four basic regression models (equation 1 separately and equation 2 in combination with each of the three functional forms (5)-(7), and four combinations of hay stocks and cattle numbers. Each of the four regression models was estimated for each of the four combinations of hay stocks and cattle numbers. The first regression model contains two terms involving time while the other three models each contain three time terms. For each model and hay stock/cattle combination we first estimated the regression with all time terms included. Those that were insignificant at the 5 percent level were eliminated sequentially until the remaining time terms were either significant at the 5 percent level or there were none remaining. Thus we have one regression for each model and each hay stock/cattle number combination for a total of 16.

Results are reported in Tables 14-17. The R^2 values are quite high (.87-.91) and vary only slightly among the various regressions. The F values are significant at the .01 percent level or better in all cases. The positive intercepts indicate consumption by livestock other than beef and dairy. The derivatives with respect to cattle numbers and prices were evaluated at the sample mean for each of the regressions. In all cases the derivative with respect to cattle numbers was positive as expected. The derivative with respect to the price of alfalfa was

[4]The 16 percent protein dairy cost index was considered.

Table 14. Estimated Alfalfa Demand Functions, Linear Model I (Equation 1)

Cattle series	Hay stock series	Intercept	CAT_t	$PALF_t$	$LPINDX_t$	$PFEED_t$	R^2	F value
Jan	Jan	1583.465 (4.32)**	.983 (11.7)**	-15.861 (-1.27)*	77.770 (2.52)**	-2.926 (-.41)	.88	59.66
Jan	May	1235.239 (3.963)**	1.023 (14.326)**	-32.114 (-3.024)**	74.668 (2.845)**	9.705 (1.598)	.91	81.93
Avg.	Jan	1614.058 (4.702)**	1.002 (12.46)**	-3.940 (-.338)	52.065 (1.756)*	-6.755 (-1.009)	.89	66.97
Avg.	May	1308.199 (4.276)**	1.032 (14.394)**	-19.396 (-1.870)*	48.738 (1.844)*	5.474 (.918)	.91	82.68

Dependent variable = $CONS_t$, 38 observations
t - statistics are in parentheses
* - significant at 10% level
** - significant at 5% level

Table 15. Estimated Alfalfa Demand Functions, Linear Model II (Equation 5)

Cattle series	Hay stock series	Intercept	CAT_t	$PALF_t \bullet CAT_t$	$LPINDX_t \bullet CAT_t$	$PFEED_t \bullet CAT_t$	R^2	F value
Jan	Jan	1721.953 (5.285)**	.944 (9.966)**	-.004 (-1.456)	.017 (2.506)**	-.000 (-.130)	.88	59.40
Jan	May	1629.953 (5.896)**	.932 (11.6)**	-.007 (-3.093)**	.016 (2.805)**	.002 (1.754)*	.91	81.97
Avg.	Jan	1618.614 (5.148)**	.995 (10.769)**	-.001 (-.480)	.012 (1.778)*	-.001 (-.822)	.89	66.68
Avg.	May	1563.722 (5.587)**	.974 (11.843)**	-.004 (-1.870)*	.011 (1.838)*	.001 (.958)	.91	82.54

Dependent variable = $CONS_t$, 38 observations
t - statistics are in parentheses
* - significant at 10% level
** - significant at 5% level

Table 16. Estimated Alfalfa Demand Functions, Deflated Linear Model (Equation 6)

Cattle series	Hay stock series	Intercept	CAT_t	$\left(\frac{PALF_t}{LPINDX_t}\right) \cdot CAT_t$	$\left(\frac{PFEED_t}{LPINDX_t}\right) \cdot CAT_t$	Year	R^2	F value
Jan	Jan	1804.672	1.141	-.010	-.025		.87	75.59
		(4.843)**	(10.368)**	(-.278)	(-1.145)			
Jan	May	817.307	.865	-.102	.038	29.478	.91	84.73
		(2.097)**	(5.948)**	(-3.01)**	(1.793)*	(2.700)**		
Avg.	Jan	1733.838	1.113	.011	-.029		.89	89.10
		(4.993)**	(11.090)**	(.327)	(-1.432)			
Avg.	May	930.647	.893	-.074	.027	23.787	.91	86.91
		(2.397)**	(6.113)**	(-2.123)**	(1.293)	(2.071)**		

Dependent variable = $CONS_t$, 38 observations
t - statistics are in parentheses
 * - significant at 10% level
** - significant at 5% level

Table 17. Estimated Alfalfa Demand Functions, Generalized Leontief Model (Equation 7)

Cattle series	Hay stock series	Intercept	CAT_t	$\left(\frac{LPINDX_t}{PALF_t}\right)^{1/2} \cdot CAT_t$	$\left(\frac{PFEED_t}{PALF_t}\right)^{1/2} \cdot CAT_t$	Year	R^2	F value
Jan	Jan	1842.214	.931	.595	-.233		.87	76.34
		(4.923)**	(5.068)**	(2.014)**	(-1.302)			
Jan	May	856.046	.160	.414	.268	28.753	.91	83.76
		(2.186)**	(.607)	(1.694)*	(1.590)	(2.644)**		
Avg.	Jan	1772.682	1.065	.460	-.265		.89	90.77
		(5.118)**	(6.324)**	(1.667)*	(-1.627)			
Avg.	May	982.869	.400	.313	.178	22.702	.91	86.20
		(2.533)**	(1.411)	(1.283)	(1.062)	(1.989)**		

Dependent variable = $CONS_t$, 38 observations
t - statistics are in parentheses
 * - significant at 10% level
** - significant at 5% level

generally negative, the only exceptions being with the average cattle/January stocks regression for the deflated linear and generalized Leontief models. (The alfalfa price coefficient is insignificant in the deflated linear case. Significance is not determined in the generalized Leontief case.) The derivatives with respect to livestock prices are positive in all regressions as expected. As mentioned, the sign of the feed price derivative is indeterminate *a priori*. Generally, we found the feed price derivatives to be negative with January stocks and positive with May stocks; however, the coefficients are insignificant at the 10 percent level in almost all cases.

In general, the intercept and cattle number terms are highly significant (5 percent or better) in all regressions, the only exceptions being two regressions in the Leontief model. The alfalfa price coefficients are significant (10 percent or better) with May stocks, but insignificant with January stocks. However, in the Leontief demand model the alfalfa price coefficient is significant (10 percent or better) in the first three regressions and marginally significant in the fourth. The livestock price coefficient is generally significant at the 10 percent level or better and, as noted, the feed price terms are generally insignificant. Time trends are significant and were retained in only four regressions (May stocks for the deflated linear and Leontief models).

Based on the statistical evidence presented in Tables 14-17, it is not clear which of the regressions should be used for further economic analysis. The R^2 values are all quite similar and the F values are very significant so these measures do not provide a useful criterion. Only two regressions can be eliminated because of implausible signs: the average cattle/ January stocks regressions for the deflated linear and Leontief models. In terms of significance of the estimated parameters, inspection of Tables 14-17 suggests that the May stocks series outperformed the January stocks series and the January cattle series generally outperformed the average cattle series. The exception is the Leontief model where January stocks gave better results.

Similar conclusions apply when evaluating the regressions on the basis of the significance of the alfalfa price terms alone. Although some preference may be given to the January cattle/May stocks regressions due to the significance of the individual terms, it does not seem possible to select the "best" model based only on the results in Tables 14-17. Comparisons with the normative results will provide additional criteria as will forecasting tests to be described in the next section.

The own-price elasticities for alfalfa demand evaluated at the sample mean, presented in Table 18, range from -.11 to .03 for January stocks and from -.21 to -.11 for May stocks. The elasticities are remarkably consistent across models for a given hay stock/cattle number series. The own-price elasticities calculated at 1982 values, presented in Table 19, range from -.2 to .03 with January hay stocks data and from -.45 to -.14 with May hay stocks data. These results suggest that the demand for hay in California is quite inelastic.

Table 18. Own-Price Elasticities for Alfalfa Demand, Evaluated at the Sample Mean

Cattle series	Hay stock series	Linear demand I, equation 1	Linear demand II, equation 5	Deflated linear demand, equation 6	Generalized Leontief demand, equation 7
January	January	-.1	-.11	-.02	-.01
January	May	-.21	-.19	-.21	-.21
Average	January	-.03	-.03	.02	.03
Average	May	-.13	-.11	-.15	-.15

Source: Computed from the regression results in Tables 14-17.

Table 19. Own-Price Elasticities for Alfalfa Demand, Evaluated at 1982 Prices and Cattle Numbers

Cattle series	Hay stock series	Linear demand I, equation 1	Linear demand II, equation 5	Deflated linear demand, equation 6	Generalized Leontief demand, equation 7
January	January	-.20	-.24	-.02	-.02
January	May	-.40	-.45	-.25	-.20
Average	January	-.05	-.06	.03	.02
Average	May	-.25	-.25	-.18	-.14

Source: Computed from the regression results in Tables 14-17.

V. COMPARISONS OF THE TWO APPROACHES TO ESTIMATING ALFALFA DEMAND

The normative demand has an own-price elasticity of -.49 when evaluated at 1982 prices. The regression elasticities range from -.45 to .03 when evaluated at 1982 prices and cattle numbers. In general the linear I and II models yielded more elastic demand estimates than the other two models. Likewise the January cattle/May stocks series yielded more elastic demands than the other data series. In particular, 1982 elasticities for the linear I and II models with the January cattle/May stocks series were -.4 and -.45, respectively —about the same as the estimated normative elasticity.

The intercept terms and time trends in the regression models with per head demands predict alfalfa consumption by livestock other than beef and dairy cattle. (This separation is not possible in the linear I model because both cattle and non-cattle livestock enter into the intercept and/or time trend terms.) The predicted consumption levels of non-cattle livestock (primarily horses) are given in Table 20.[5] Predicted non-cattle consumption ranges from 1.6 to 1.8 million tons per year for those regressions without time trends. These estimates are remarkably similar to the 1.7 million ton estimate for horses and other non-cattle livestock in the normative analysis. One regression with time trend had a plausible value for non-cattle livestock (1.9 million tons per year); however, the other regressions had implausible values (2.4 to 3.2 million tons per year).

The derivative of consumption with respect to cattle numbers in the regression models provides estimates of average annual alfalfa consumption per head of cattle. The predicted 1982 levels, given in Table 21, range from .98 to 1.1 tons per year for the aggregate cattle regressions without time trends. These are quite close to an average of 1.1 tons per animal per year estimated from Table 13 in the normative analysis. However, the regressions with time trends predict per head of cattle consumptions of .71-.78 tons per year, which are implausible results, based on the normative analysis.

The normative and positive demand relations were tested by forecasting 1983 consumption given 1983 prices and cattle numbers. Actual alfalfa consumption in 1983 was estimated as alfalfa production plus net imports minus change in carryover stocks using MNS data. This amounted to 6.98 or 7.29 million tons depending on whether May or January carry-over stocks are used. Livestock prices, feed prices and cattle numbers were obtained from the same sources used in estimating the demand relations. Consumption was forecast using the 16 regressions reported in Tables 14-17. In all cases predicted consumption was less than actual consumption. The magnitude of the errors ranged from 4.4 percent to 12 percent of actual consumption and the root mean squared percentage error was 8.5 percent for the 16 regressions (Pindyck and Rubinfeld, 1981). In contrast to the statistical results, the average cattle regressions generally performed better than the January cattle regressions. The May hay stocks regressions performed slightly better than the January stocks regressions. Generally the linear I model was the poorest in forecasting consumption and the linear II model was only slightly better. The deflated linear and generalized Leontief models performed about the same.

Alfalfa price data for testing the normative demand model were obtained from MNS for 1983 for each of the four consumption regions and then deflated to 1982 dollars using a USDA production cost index. Alfalfa consumption by milk cows was estimated from Table 9 and then adjusted for the change in milk cow numbers in 1983 in these regions. Alfalfa consumption by non-milk livestock was then estimated from Table 13 after adjusting for changes in numbers of beef and non-milk dairy cattle in 1983. The resulting consumption was estimated as 6.97 million tons. This underestimated actual consumption by 0.1 - 4.4 percent depending on whether actual consumption is measured using changes in January hay stocks or changes in May carryovers.

[5] These predicted consumption levels are the regression intercepts except for the deflated linear and Leontief models which include linear trends under the May stock series.

Table 20. Econometric Estimates of Consumption By Livestock Other Than Beef and Dairy Cattle in 1982

Cattle series	Hay stock series	Linear II, equation 5	Deflated linear, equation 6	Generalized Leontief, equation 7
		— — — — — — — —	1,000 tons	— — — — — — — —
Jan.	Jan	1722	1804	1842
Jan.	May	1630	3235	2358
Avg.	Jan	1618	1734	1772
Avg.	May	1564	2881	1862

Source: Computed from regression results, Tables 15-17.

Table 21. Econometric Estimates of Annual Cattle Consumption Per Head, 1982

		Regression Models			
Cattle series	Hay stock series	Linear demand I, equation 1	Linear demand II, equation 5	Deflated linear demand, equation 6	Generalized Leontief demand, equation 7
		— — — — — — — —	tons per animal		— — — — — — — —
Jan	Jan	.98	1.04	.99	.98
Jan	May	1.02	.99	.71	.71
Avg	Jan	1.00	1.10	1.02	1.00
Avg	May	1.03	1.04	.77	.78

Source: Computed from regression results, Tables 14-17.

VI. CONCLUSIONS

Demand for alfalfa in California was estimated using both normative and positive approaches. The normative analysis yielded an own-price elasticity of -1.23 for alfalfa consumption by milk cows and an elasticity of -.49 for aggregate statewide alfalfa demand. The elasticity for milk cow consumption appears to be a reliable estimate given (1) the level of detail in the LP model used to estimate demand on an individual milk cow basis, (2) the fact that this model (or similar models) is currently used by producers in making feeding decisions, and (3) the extensive data set available for aggregating individual demand relations. The elasticity of total demand is a lower bound on the true elasticity since the demand by non-milk livestock was assumed to be perfectly inelastic. The error involved in the perfectly inelastic assumption is likely to be small because (1) alfalfa consumption makes up a small share of the diet of these non-milk animals relative to the milk cow share and (2) econometric demand functions all produced 1982 own-price elasticities less than -.49. When the normative demand model was tested by estimating 1983 consumption using 1983 prices and livestock numbers, the forecast error ranged between 0.1 and 4.4 percent depending on the hay stock series used to estimate actual consumption in 1983.

The demand regressions generally performed well. They had high R^2 values, significant F statistics, and correct signs in almost all cases. Predicted levels of per-head cattle consumption and total non-cattle consumption (mainly horses) matched normative estimates of the same quantities remarkably well. The exceptions were the regression with time trends which generally produced implausible values for per-head cattle consumption and total non-cattle consumption.[6]

When the cattle regressions were tested by forecasting 1983 consumption, consumption was underestimated in all cases. The magnitude of the error ranged from 4.4 percent to 12 percent of actual consumption with a root mean square percentage error of 8.5 percent. Thus the normative forecast was better than the positive forecast in light of the smaller forecast error of the former.

Ignoring the two regressions with positive own-price elasticities, the regressions yielded elasticities ranging from -.45 to -.02 depending on the functional forms and the data set used to estimate consumption and cattle numbers. While these estimates are all consistent with an inelastic demand for alfalfa, the range of estimates significantly reduces their usefulness for further quantitative analysis. Note that it does not seem possible to distinguish among these estimates based on performance over the sample period, or a single year's forecasting test. Further, the statistically estimated elasticities are generally less than the normative elasticity which we take to be a reliable lower bound on the true elasticity. These problematic results seem noteworthy given that demand relations are typically estimated econometrically for the purpose of determining elasticities.

[6]These regressions considered linear and quadratic time trends in both per-head cattle consumption and total non-cattle consumption. The implausible results provide some evidence for the point earlier that *ad hoc* time trends may be a very imperfect means of capturing technical change.

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Cattle Numbers, Price of Milk, Price of Beef

1945-83: California Crop and Livestock Reporting Service, *California Livestock Statistics,* various issues.

Hay Production

1945-78: California Crop and Livestock Reporting Service, *Field Crops Statistics,* various isssues.

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Barley, Corn, Oats Production and Prices

1945-78: California Crop and Livestock Reporting Service, *Field Crops Statistics,* various issues.

1978-82: California Crop and Livestock Reporting Service, *Field Crop Review,* various issues.

APPENDIX

Table A1. Average Nutrient Analyses of Feeds

04/23/84 <------------------------ 1 0 0 % D M ------------------------>

FEED #	FEED NAME	%DM	NE(L)	ENE	TDN	%CP	%FAT	%EFF CF	%ADF	%ASH	%CA	%P	%NPN	MAX %CDM MLK	MAX %CDM DRY	MAX %TDM HFR
1	ALMOND HULLS,13% CF	91	0.57	547	56	4.4	4.0	7	27	6.6	0.23	0.11	0.00	20.0	100.0	45.0
2	ALMOND HULLS,15% CF	91	0.53	516	53	4.2	4.0	9	31	6.6	0.23	0.11	0.00	20.0	100.0	45.0
3	ALMOND HULLS & SHELL	91	0.45	453	45	3.3	2.2	11	40	9.9	0.22	0.11	0.00	20.0	100.0	45.0
4	APPLE POMACE,DRIED	89	0.71	672	69	4.9	5.1	17	26	2.2	0.13	0.12	0.00	20.0	100.0	45.0
5	BAKERY WASTE,DRIED	92	0.94	880	89	11.9	14.9	1	1	1.7	0.07	0.11	0.00	15.0	15.0	15.0
6	BARLEY,49#	89	0.88	828	84	10.7	2.1	4	5	2.3	0.05	0.37	0.00	80.0	100.0	100.0
7	BARLEY,46-48#	89	0.86	807	82	10.7	2.1	7	9	2.9	0.05	0.37	0.00	80.0	100.0	100.0
8	BARLEY,LIGHT WT	89	0.80	755	77	13.4	2.1	8	11	3.6	0.05	0.37	0.00	80.0	100.0	100.0
9	BEET PULP,DRIED	91	0.81	765	78	8.0	0.7	22	34	3.9	0.75	0.11	0.00	40.0	100.0	40.0
10	BEET PULP,MOL. DRIED	92	0.81	765	78	9.9	0.6	17	26	6.4	0.61	0.11	0.00	40.0	100.0	40.0
11	BONE MEAL, STEAMED	95	0.12	120	16	12.7	1.3	2	3	86.0	30.51	14.31	0.00	100.0	100.0	100.0
12	BREAD,DRIED	92	0.94	880	89	13.3	3.1	1	1	2.0	0.09	0.16	0.00	15.0	15.0	25.0
13	BREWERS GRAIN,DR 25P	92	0.68	640	66	26.0	7.2	16	23	4.1	0.29	0.54	0.00	25.0	100.0	30.0
14	BREWERS GRAIN,CALIF	92	0.61	578	60	22.2	6.3	20	29	4.1	0.29	0.54	0.00	25.0	100.0	30.0
15	BREWERS GRAIN,WET	24	0.69	651	67	26.0	7.2	16	23	4.1	0.29	0.54	0.00	25.0	100.0	30.0
16	CITRUS PULP,DRIED	90	0.80	755	77	6.9	3.8	14	23	7.0	2.07	0.13	0.00	25.0	100.0	30.0
17	COCONUT MEAL,EXP	93	0.85	796	81	21.9	7.4	13	20	7.2	0.23	0.66	0.00	50.0	100.0	30.0
18	COCONUT MEAL,SOL	92	0.77	724	74	23.1	2.7	16	24	7.3	0.18	0.66	0.00	50.0	100.0	30.0
19	CORN EARS,GROUND	87	0.84	786	80	9.3	3.6	9	12	1.4	0.05	0.26	0.00	80.0	100.0	100.0
20	CORN GRAIN,CRACKED	89	0.84	786	80	10.0	4.3	2	3	1.3	0.03	0.31	0.00	80.0	100.0	100.0
21	CORN GRAIN,GR OR RLD	89	0.92	869	88	10.0	4.3	2	3	1.3	0.03	0.31	0.00	80.0	100.0	100.0
22	CORN GLUTEN FEED	90	0.86	807	82	28.1	2.8	9	12	8.6	0.33	0.86	0.00	25.0	100.0	15.0
23	CORN GLUTEN MEAL	91	0.88	828	84	65.9	2.4	3	4	3.9	0.18	0.51	0.00	25.0	100.0	15.0
24	COTTONSEED MEAL,41 E	94	0.80	755	77	43.6	6.7	13	20	7.2	0.17	1.28	0.00	25.0	100.0	30.0
25	COTTONSEED MEAL,41 S	92	0.78	734	75	44.8	2.3	13	20	6.9	0.17	1.31	0.00	25.0	100.0	30.0
26	COTTONSEED MEAL,50 S	92	0.78	734	75	54.0	2.3	9	12	6.9	0.17	1.09	0.00	25.0	100.0	30.0
27	COTTONSEED,WHOLE	93	1.04	973	98	24.9	21.1	18	29	3.9	0.15	0.73	0.00	20.0	100.0	30.0
28	DIAMMONIUM PHOSPHATE	96	0.00	0	0	142.2	0.0	0	0	23.8	0.00	25.56	22.76	1.0	1.0	1.0
29	DICALCIUM PHOSPHATE	96	0.00	0	0	0.0	0.0	0	0	86.8	23.70	18.84	0.00	100.0	100.0	100.0
30	DISODIUM PHOSPHATE	96	0.00	0	0	0.0	0.0	0	0	88.9	0.00	22.78	0.00	100.0	100.0	100.0
31	DIST CORN GRAINS,DR	92	0.88	828	84	29.5	9.9	13	20	2.7	0.10	0.40	0.00	25.0	100.0	25.0
32	FAT,ANIMAL	99	1.97	1847	182	0.0	96.9	0	0	0.0	0.00	0.00	0.00	3.0	3.0	3.0
33	FERMENTATION SOLUBLE	93	0.92	869	88	28.9	5.7	4	6	7.2	0.38	1.47	0.00	10.0	10.0	10.0
34	GRAPE POMACE,DRIED	91	0.28	266	30	12.7	7.6	17	54	5.5	0.01	0.01	0.00	5.0	5.0	15.0
35	HEGARI GRAIN	88	0.84	786	80	11.7	2.9	2	9	1.8	0.03	0.33	0.00	50.0	100.0	30.0
36	HOMINY FEED,5% FAT	91	0.97	911	92	11.8	7.2	6	12	3.0	0.06	0.58	0.00	50.0	100.0	30.0
37	HOMINY FEED,LOW FAT	91	0.95	890	90	11.3	5.2	5	11	2.6	0.06	0.58	0.00	50.0	100.0	30.0
38	KELP,DRIED	91	0.30	287	32	7.1	0.5	7	10	38.6	2.72	0.31	0.00	5.0	5.0	30.0
39	LIMESTONE,GROUND	100	0.00	0	0	0.0	0.0	0	0	95.8	36.07	0.02	0.00	100.0	100.0	100.0
40	LINSEED MEAL,35 EXP	91	0.85	796	81	38.8	5.9	10	17	6.3	0.43	0.93	0.00	25.0	100.0	30.0
41	LINSEED MEAL,35 SOL	91	0.79	744	76	38.6	1.1	10	17	6.4	0.43	0.91	0.00	25.0	100.0	30.0
42	MALT,BARLEY	91	0.92	869	88	15.8	1.8	2	3	2.5	0.09	0.52	0.00	20.0	100.0	30.0
43	MALT,BARLEY, NW	91	0.80	755	77	32.2	7.2	18	24	4.0	3.22	0.57	0.00	20.0	100.0	30.0
44	MILO,CAL OR MIDWEST	88	0.84	786	80	11.7	3.3	2	9	2.3	0.03	0.33	0.00	50.0	100.0	30.0
45	MILO,SOUTHWEST	88	0.79	744	76	10.6	3.1	3	9	2.3	0.03	0.33	0.00	50.0	100.0	30.0
46	MOLASSES,CANE	75	0.75	703	72	4.3	0.0	0	0	12.6	1.19	0.11	0.00	8.5	8.5	10.0
47	MOLASSES,CANE,3% PO4	75	0.72	682	70	4.2	0.0	0	0	12.2	1.15	0.95	0.00	8.5	8.5	10.0
48	MONOAMMONIUM PHOSPHT	98	0.00	0	0	70.2	0.0	0	0	23.8	0.53	24.49	11.84	1.0	1.0	1.0
49	MONOSODIUM PHOSPHATE	87	0.00	0	0	0.0	0.0	0	0	88.9	0.00	25.80	0.00	100.0	100.0	100.0
50	OATS,LIGHT WT	91	0.66	620	64	13.3	5.0	17	25	5.2	0.10	0.36	0.00	80.0	100.0	90.0

(Continued)

Table A1. Average Nutrient Analyses of Feeds (Continued)

04/23/84 <------------------------ 1 0 0 % D M ------------------------>

FEED #	FEED NAME	%DM	NE(L)	ENE	TDN	%CP	%FAT	%EFF CF	%ADF	%ASH	%CA	%P	%NPN	MAX %CDM MLK	MAX %CDM DRY	MAX %TDM HFR
51	OATS,PCS	91	0.80	755	77	10.1	6.0	12	17	4.1	0.10	0.36	0.00	80.0	100.0	90.0
52	ORANGE PULP,DRIED	88	0.81	765	78	8.5	1.7	10	16	3.8	0.71	0.11	0.00	25.0	100.0	30.0
53	OYSTERSHELL FLOUR	100	0.00	0	0	1.0	0.0	0	0	89.8	38.22	0.07	0.00	100.0	100.0	100.0
54	PEAS,CULL	90	0.87	817	83	26.5	1.2	6	9	3.1	0.13	0.47	0.00	25.0	100.0	30.0
55	PINEAPPLE BRAN	87	0.76	713	73	4.6	1.9	18	28	3.4	0.24	0.12	0.00	25.0	100.0	30.0
56	POTATOES,DRIED	90	0.80	770	77	8.7	0.3	2	3	4.8	0.07	0.21	0.00	25.0	100.0	45.0
57	RICE BRAN AND HULLS	91	0.31	297	33	6.7	5.6	17	53	19.1	0.08	0.59	0.00	5.0	100.0	10.0
58	RICE BRAN,13% FAT	91	0.79	744	76	14.0	15.1	12	16	14.8	0.07	1.62	0.00	20.0	100.0	30.0
59	RICE BRAN,SOL	90	0.64	599	62	15.9	3.4	13	17	15.1	0.07	1.62	0.00	20.0	100.0	30.0
60	RICE GRAIN,POLISHED	89	0.88	828	84	8.2	2.0	1	2	5.8	0.03	0.12	0.00	25.0	100.0	30.0
61	RYE GRAIN	90	0.83	786	80	13.8	1.9	3	4	2.1	0.07	0.36	0.00	10.0	100.0	100.0
62	SAFFLOWER SEEDS	92	0.94	880	89	19.5	32.0	16	40	3.1	0.25	0.67	0.00	20.0	100.0	30.0
63	SAFFLOWER MEAL,20 S	92	0.56	526	55	23.9	1.1	17	39	4.3	0.37	0.80	0.00	20.0	100.0	30.0
64	SAFFLOWER MEAL,42 S	90	0.79	744	76	46.5	1.1	13	20	7.1	0.44	1.41	0.00	20.0	100.0	30.0
65	SCREENINGS,GOOD GR	90	0.72	682	70	13.5	5.2	9	12	9.8	0.46	0.32	0.00	20.0	100.0	45.0
66	SCREENINGS,REFUSE	90	0.57	536	56	11.5	4.3	16	40	10.6	0.46	0.32	0.00	20.0	100.0	45.0
67	SOD TRIPOLYPHOSPHATE	96	0.00	0	0	0.0	0.0	0	0	0.0	0.00	25.98	0.00	100.0	100.0	100.0
68	SOYBEAN MEAL,44 SOL	89	0.85	796	81	49.6	1.4	7	10	6.8	0.36	0.75	0.00	50.0	100.0	30.0
69	SOYBEAN MEAL,48 SOL	89	0.85	796	81	54.0	1.4	3	5	6.8	0.36	0.75	0.00	50.0	100.0	30.0
70	SUNFLOWER MEAL,EXP	93	0.72	682	70	44.1	5.2	13	33	6.3	0.46	1.12	0.00	25.0	100.0	30.0
71	SUNFLOWER MEAL,SOL	93	0.67	630	65	50.3	1.2	12	30	6.3	0.40	1.10	0.00	25.0	100.0	30.0
72	UREA,46% N	90	0.00	0	0	287.5	0.0	0	0	10.0	0.00	0.00	46.00	1.5	1.5	1.0
73	WHEAT BRAN	89	0.72	682	70	18.0	5.0	11	12	6.8	0.12	1.32	0.00	25.0	100.0	30.0
74	WHEAT MILL RUN	90	0.77	724	74	17.0	4.8	9	10	5.8	0.10	1.13	0.00	25.0	100.0	30.0
75	WHEAT,SOFT,PCS	86	0.92	869	88	12.0	2.2	3	4	2.1	0.06	0.41	0.00	50.0	100.0	30.0
76	WHEY,LIQUID	7	0.81	765	78	14.0	4.3	0	0	11.0	0.98	0.81	0.00	10.0	10.0	10.0
77	WHEY,COND,42% SOLIDS	42	0.81	765	78	14.0	4.3	0	0	11.0	0.98	0.81	0.00	10.0	10.0	10.0
78	WHEY PRODUCT,DRIED	93	0.81	765	78	17.0	1.4	0	0	16.7	1.67	1.11	0.00	10.0	10.0	10.0
79	YEAST,BREWERS,DRIED	93	0.81	765	78	48.3	0.8	3	4	7.7	0.14	1.54	0.00	5.0	5.0	5.0
80	SALT	90	0.00	0	0	0.0	0.0	0	0	100.0	0.00	0.00	0.00	100.0	100.0	100.0
81	ALFALFA HAY,21% MCF	90	0.64	511	62	22.0	2.7	22	29	9.3	1.60	0.30	0.00			100.0
82	ALFALFA HAY,24% MCF	90	0.59	478	58	19.5	2.7	26	33	9.3	1.40	0.25	0.00			100.0
83	ALFALFA HAY,28% MCF	90	0.55	428	54	15.0	2.7	30	37	9.3	1.20	0.20	0.00			100.0
84	ALFALFA SILAGE,36 DM	36	0.59	467	58	19.5	2.7	26	33	9.3	1.40	0.25	0.00			100.0
85	BARLEY HAY	87	0.58	433	57	8.9	2.2	26	33	7.6	0.21	0.30	0.00			100.0
86	CORN,CANNERY WASTE	23	0.65	505	63	8.8	2.7	22	29	5.9	0.34	0.63	0.00			100.0
87	CORN,CANNERY SILAGE	29	0.65	505	63	8.8	2.7	27	34	5.9	0.34	0.63	0.00			100.0
88	CORN SILAGE,25% DM	25	0.67	520	65	8.0	2.7	24	31	5.7	0.27	0.20	0.00			100.0
89	CORN SILAGE,30% DM	30	0.67	520	65	8.0	2.7	24	31	5.7	0.27	0.20	0.00			100.0
90	COTTONSEED HULLS	90	0.37	254	38	4.3	1.0	50	71	2.9	0.16	0.10	0.00			100.0
91	OAT HAY	88	0.55	405	54	9.2	3.0	31	36	7.7	0.26	0.24	0.00			100.0
92	OAT AND VETCH HAY	88	0.59	442	58	14.1	3.0	31	40	9.1	0.72	0.29	0.00			100.0
93	OAT SILAGE,BOOT	22	0.64	498	62	11.0	4.0	26	33	8.3	0.47	0.10	0.00			100.0
94	OAT SILAGE,DOUGH	30	0.60	475	59	9.7	4.0	34	42	8.3	0.47	0.33	0.00			100.0
95	PINEAPPLE GREENCHOP	18	0.57	433	56	7.6	2.2	27	35	6.4	0.28	0.08	0.00			50.0
96	PINEAPPLE PRESSCAKE	21	0.74	636	71	5.3	0.7	26	34	2.6	0.28	0.08	0.00			30.0
97	PINEAPPLE STUMPMEAL	46	0.66	541	64	3.0	0.8	22	30	1.9	0.28	0.08	0.00			30.0
98	SORGHUM SILAGE,30 DM	29	0.56	445	55	8.3	2.7	26	33	9.0	0.32	0.18	0.00			100.0
99	SUDANGRASS HAY	89	0.55	405	54	11.0	1.8	29	42	9.0	0.56	0.31	0.00			100.0
100	SUGARCANE BAGASSE	55	0.38	202	39	1.5	0.4	49	56	5.5	0.35	0.27	0.00			50.0
101	SUGARCANE STRIPPINGS	45	0.44	270	44	3.6	0.9	45	51	10.3	0.35	0.27	0.00			30.0
102	UREA-CORN SILAGE	30	0.67	520	65	12.7	2.7	24	31	5.7	0.27	0.20	0.77			100.0

Source: Natural Research Council, Committee on Animal Nutrition. *Nutrient Requirements of Domestic Animals, No. 3: Nutrient Requirements of Dairy Cattle.* 5th Revised Edition, National Academy of Sciences, Washington, 1978.

Note: Feed numbers are the identification numbers for the Dairy Ration Program and are assigned by Animal Science Extension, UC Davis.

Table A2.
A Sample Print-Out of the California
Dairy Ration Program

C A L I F O R N I A   D A I R Y   R A T I O N
(MAXIMUM INCOME ABOVE FEED COSTS)

SOUTHERN CALIFORNIA   1/18/83   21:43:09 HOURS

SPECIFICATIONS:

PRODUCTION CURVE MAXIMUM............	= 60 LBS
AVERAGE MILK FAT....................	= 3.6 %
AVERAGE COW WEIGHT..................	= 1400 LBS
BLEND PRICE.........................	= $ 13.24/CWT
NE(L) FOR ACTIVITY..................	= 10 % OF MAINTENANCE
FIRST LACTATION HEIFERS IN GROUP...	= 30 %
SECOND LACTATION HEIFERS IN GROUP..	= 25 %

FEEDS USED IN RATION:	LB/DAY AS FED	%ROUGHAGE AS FED	%ROUGHAGE DM	PRICE $/CWT	---RANGE--- LOWER	---RANGE--- UPPER	---CONSTRAINTS--- AS FED -POUNDS- MIN	AS FED -POUNDS- MAX	100% DM -%ROUGH- MIN	100% DM -%ROUGH- MAX
COTTONSEED HULLS	11.00	52.4	52.4	2.00	1.99	2.71				
ALFALFA HAY,24% MCF	10.00	47.6	47.6	6.00	5.29	*****	10.0			
TOTAL ROUGHAGE...	21.00	(18.90 LBS DM)								
		%CONCENTRATE AS FED	%CONCENTRATE DM				AS FED -POUNDS- MIN	AS FED -POUNDS- MAX	100% DM -%CONC.- MIN	100% DM -%CONC.- MAX
BEET PULP,DRIED	13.15	39.1	38.9	6.15	6.08	6.55				40.0
COTTONSEED MEAL,41 E	8.19	24.4	25.0	7.60	5.68	7.70				25.0
ALMOND HULLS,15% CF	6.77	20.1	20.0	3.15	0.83	3.28				20.0
CORN GRAIN,GR OR RLD	3.87	11.5	11.2	6.50	6.25	6.51				80.0
COTTONSEED,WHOLE	1.54	4.6	4.6	8.65	8.63	9.07				20.0
DICALCIUM PHOSPHATE	0.09	0.3	0.3	16.00	3.07	18.32				
TOTAL CONCENTRATE.	33.60*	(30.78 LBS DM)								

*NOTE: PROVIDE SALT FREE CHOICE OR AS 0.5% OF CONCENTRATE MIX.
PROVIDE OTHER ESSENTIAL MINERALS NOT SUPPLIED IN ADEQUATE AMOUNTS
BY FEEDS IN RATION LISTED ABOVE.

ROUGHAGE:CONCENTRATE RATIO = 38:62 (DM)

	LB/COW	$/COW	PRICE PER CWT	LOWER RANGE	UPPER RANGE
OPTIMUM DAILY MILK PRODUCTION:	56.0	7.41	13.24	10.81	14.41
TOTAL FEED COST		2.86			
TOTAL DAILY INCOME ABOVE FEED COST:		4.55			

ESTIMATED ANALYSIS: (AS FED)	CONCENTRATE	ROUGHAGE	TOTAL RATION	-CONSTRAINTS-- MIN	MAX
DRY MATTER PCT	91.61 %	90.00 %	90.99 %	35.00%	
NE(L)	0.71 MCAL/LB	0.43 MCAL/LB	0.60 MCAL/LB		
TDN	68.50 %	42.77 %	58.60 %		
CRUDE PROTEIN	15.69 %	10.38 %	13.65 %	13.65%	
CRUDE FAT	3.86 %	1.63 %	3.00 %		
EFF. CF	13.43 %	34.71 %	21.62 %	15.47%	
ADF	23.91 %	47.61 %	33.03 %		
ASH	4.78 %	5.35 %	5.00 %		
CALCIUM	0.42 %	0.68 %	0.52 %	0.49%	
PHOSPHORUS	0.47 %	0.15 %	0.35 %	0.35%	
CA:PHOS RATIO	0.90	4.38	1.50	1.50	
NPN	0.00 %	0.00 %	0.00 %		0.45%
COST AS FED	$ 6.08 /CWT	$ 3.90 /CWT	$ 5.24 /CWT		
COST DRY MATTER	$ 6.64 /CWT	$ 4.34 /CWT	$ 5.76 /CWT		

FEEDS NOT USED IN RATION:	PRICE AT FORMULATION	PRICE OPPORTUNITY
BARLEY,46-48#	6.40	6.10
COTTONSEED MEAL,41 S	8.25	7.35
HOMINY FEED,LOW FAT	7.00	6.98
MONOAMMONIUM PHOSPHT	29.00	4.38
WHEAT MILL RUN	6.45	5.88
WHEAT,SOFT,PCS	6.66	6.40

Table A3. Percentage of Cows in Different Production Groups at Different Lactation Stages

Petaluma

Production Group	LACTATION NUMBER 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	TOTAL
1000	0.17	0.02	0.01	0.01	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.22
2000	0.21	0.15	0.05	0.04	0.01	0.02	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.50
3000	0.03	0.07	0.07	0.02	0.03	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.24
4000	0.02	0.01	0.01	0.01	0.01	0.02	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08
5000	0.05	0.01	0.03	0.01	0.01	0.01	0.01	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.14
6000	0.09	0.03	0.02	0.01	0.01	0.01	0.02	0.01	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.22
7000	0.27	0.08	0.04	0.03	0.02	0.03	0.03	0.02	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.55
8000	0.47	0.19	0.09	0.07	0.06	0.05	0.03	0.03	0.02	0.00	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.05
9000	0.68	0.27	0.16	0.10	0.07	0.09	0.09	0.04	0.03	0.03	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.58
10000	1.11	0.47	0.28	0.12	0.12	0.10	0.11	0.08	0.05	0.04	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.52
11000	1.60	0.76	0.42	0.28	0.20	0.18	0.12	0.09	0.07	0.04	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.78
12000	2.42	0.84	0.57	0.39	0.28	0.23	0.16	0.14	0.09	0.04	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.20
13000	2.77	1.26	0.79	0.49	0.39	0.29	0.22	0.17	0.10	0.05	0.02	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.60
14000	3.36	1.58	1.02	0.61	0.46	0.37	0.23	0.22	0.10	0.05	0.03	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	8.08
15000	3.47	1.96	1.37	0.82	0.61	0.44	0.31	0.21	0.16	0.08	0.03	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9.49
16000	3.15	2.34	1.62	1.06	0.69	0.49	0.34	0.24	0.10	0.06	0.03	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.14
17000	2.41	2.51	1.66	1.16	0.80	0.51	0.29	0.24	0.13	0.08	0.02	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9.84
18000	1.78	2.31	1.83	1.29	0.81	0.54	0.34	0.24	0.16	0.05	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9.37
19000	1.16	2.15	1.81	1.26	0.86	0.57	0.29	0.20	0.10	0.02	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	8.43
20000	0.63	1.70	1.45	1.02	0.75	0.54	0.33	0.17	0.08	0.02	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.71
21000	0.34	1.26	1.28	0.86	0.64	0.42	0.22	0.14	0.06	0.03	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.27
22000	0.15	0.85	0.89	0.79	0.47	0.35	0.17	0.08	0.04	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.81
23000	0.08	0.58	0.51	0.46	0.39	0.22	0.12	0.08	0.02	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.47
24000	0.02	0.31	0.42	0.33	0.27	0.13	0.10	0.04	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.63
25000	0.01	0.18	0.19	0.21	0.18	0.08	0.06	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.94
26000	0.01	0.07	0.12	0.15	0.09	0.07	0.02	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.56
27000	0.00	0.04	0.06	0.07	0.06	0.04	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.30
28000	0.00	0.02	0.03	0.05	0.02	0.03	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.15
29000	0.00	0.01	0.01	0.02	0.02	0.01	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08
30000	0.00	0.00	0.01	0.01	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03
31000	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02
32000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
33000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
34000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
35000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
36000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
37000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
38000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
39000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
40000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
41000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
42000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
43000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
44000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
45000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
46000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
47000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
48000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
49000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
50000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL	26.43	22.05	16.81	11.77	8.34	5.88	3.67	2.47	1.37	0.64	0.27	0.13	0.05	0.02	0.00	0.00	0.00	0.00	0.00	0.00	100.00

(Continued)

Table A3. Percentage of Cows in Different Production Groups at Different Lactation Stages (Continued)

North Valley

Production Group	LACTATION NUMBER																				TOTAL
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	
1000	0.18	0.07	0.03	0.02	0.02	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.35
2000	0.13	0.10	0.07	0.04	0.03	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.40
3000	0.03	0.04	0.02	0.02	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.15
4000	0.04	0.02	0.02	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.12
5000	0.10	0.04	0.03	0.02	0.02	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.24
6000	0.15	0.08	0.05	0.03	0.02	0.02	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.38
7000	0.31	0.12	0.08	0.05	0.04	0.03	0.02	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.68
8000	0.53	0.23	0.12	0.07	0.06	0.04	0.04	0.02	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.13
9000	0.86	0.35	0.19	0.12	0.07	0.06	0.05	0.03	0.02	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.78
10000	1.37	0.58	0.30	0.19	0.14	0.10	0.08	0.04	0.02	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.86
11000	2.02	0.84	0.48	0.29	0.19	0.14	0.10	0.07	0.04	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.20
12000	2.61	1.18	0.63	0.37	0.30	0.18	0.13	0.07	0.05	0.03	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.60
13000	3.26	1.56	0.88	0.51	0.36	0.24	0.15	0.10	0.06	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.20
14000	3.69	1.85	1.10	0.69	0.46	0.32	0.20	0.12	0.07	0.03	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	8.59
15000	3.68	2.19	1.38	0.81	0.53	0.34	0.21	0.13	0.06	0.03	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9.41
16000	3.48	2.32	1.55	1.02	0.64	0.42	0.24	0.14	0.06	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9.92
17000	2.88	2.35	1.67	1.06	0.70	0.45	0.25	0.12	0.06	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9.61
18000	2.23	2.32	1.62	1.09	0.73	0.42	0.24	0.13	0.06	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	8.88
19000	1.52	2.01	1.55	1.05	0.66	0.43	0.20	0.10	0.05	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.62
20000	0.96	1.68	1.30	0.94	0.60	0.34	0.19	0.08	0.03	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.16
21000	0.58	1.32	1.10	0.78	0.49	0.32	0.14	0.06	0.03	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.84
22000	0.29	0.92	0.82	0.64	0.39	0.21	0.10	0.05	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.46
23000	0.16	0.66	0.61	0.44	0.30	0.16	0.07	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.46
24000	0.08	0.43	0.40	0.30	0.21	0.10	0.06	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.60
25000	0.03	0.27	0.25	0.20	0.16	0.06	0.03	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.02
26000	0.02	0.14	0.15	0.14	0.08	0.05	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.59
27000	0.00	0.07	0.08	0.08	0.05	0.03	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.34
28000	0.00	0.04	0.05	0.04	0.03	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.19
29000	0.00	0.01	0.03	0.02	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10
30000	0.00	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04
31000	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02
32000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
33000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
34000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
35000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
36000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
37000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
38000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
39000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
40000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
41000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
42000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
43000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
44000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
45000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
46000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
47000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
48000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
49000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
50000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL	31.21	23.81	16.59	11.07	7.33	4.53	2.60	1.39	0.67	0.28	0.11	0.04	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.00

(Continued)

Table A3. Percentage of Cows in Different Production Groups at Different Lactation Stages (Continued)

South Valley

Production Group	LACTATION NUMBER 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	TOTAL
1000	0.07	0.02	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.12
2000	0.05	0.02	0.02	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.12
3000	0.03	0.02	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.09
4000	0.04	0.02	0.02	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11
5000	0.07	0.03	0.03	0.02	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.19
6000	0.10	0.05	0.04	0.03	0.02	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.28
7000	0.22	0.09	0.06	0.04	0.02	0.02	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.49
8000	0.33	0.17	0.09	0.07	0.05	0.03	0.02	0.02	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.80
9000	0.63	0.28	0.14	0.09	0.06	0.04	0.03	0.02	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.33
10000	1.07	0.45	0.26	0.16	0.11	0.06	0.05	0.04	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.23
11000	1.65	0.68	0.37	0.20	0.16	0.12	0.07	0.04	0.03	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.37
12000	2.45	0.99	0.58	0.35	0.20	0.16	0.10	0.07	0.03	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.96
13000	3.39	1.44	0.88	0.53	0.33	0.21	0.12	0.09	0.05	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.06
14000	4.04	1.91	1.18	0.70	0.39	0.27	0.16	0.11	0.06	0.02	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	8.85
15000	4.13	2.32	1.49	0.89	0.52	0.36	0.20	0.10	0.07	0.03	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.12
16000	3.73	2.61	1.74	1.06	0.66	0.42	0.26	0.14	0.07	0.03	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.73
17000	3.08	2.68	1.89	1.22	0.70	0.45	0.21	0.13	0.07	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.48
18000	2.18	2.58	1.94	1.22	0.77	0.46	0.24	0.13	0.06	0.03	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9.62
19000	1.41	2.25	1.72	1.19	0.71	0.39	0.20	0.11	0.04	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	8.05
20000	0.87	1.80	1.47	1.06	0.65	0.35	0.19	0.09	0.04	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.54
21000	0.53	1.31	1.15	0.86	0.52	0.28	0.16	0.07	0.03	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.92
22000	0.27	0.93	0.88	0.70	0.41	0.21	0.11	0.04	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.60
23000	0.15	0.58	0.59	0.46	0.26	0.17	0.08	0.03	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.33
24000	0.08	0.35	0.35	0.31	0.20	0.12	0.04	0.03	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.48
25000	0.04	0.21	0.24	0.20	0.12	0.07	0.03	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.91
26000	0.02	0.15	0.14	0.12	0.08	0.04	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.58
27000	0.01	0.08	0.07	0.06	0.03	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.29
28000	0.00	0.04	0.04	0.03	0.02	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.16
29000	0.00	0.02	0.03	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.09
30000	0.00	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05
31000	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03
32000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
33000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
34000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
35000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
36000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
37000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
38000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
39000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
40000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
41000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
42000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
43000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
44000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
45000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
46000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
47000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
48000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
49000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
50000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL	30.61	24.09	17.45	11.67	7.07	4.30	2.36	1.30	0.66	0.27	0.08	0.04	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	100.00

(Continued)

Table A3. Percentage of Cows in Different Production Groups at Different Lactation Stages (Continued)

Southern California

Production Group	LACTATION NUMBER 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	TOTAL
1000	0.05	0.02	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.12
2000	0.07	0.03	0.02	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.15
3000	0.05	0.02	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11
4000	0.05	0.01	0.01	0.01	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.12
5000	0.04	0.02	0.02	0.01	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.13
6000	0.06	0.03	0.03	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.17
7000	0.11	0.06	0.05	0.03	0.01	0.02	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.31
8000	0.20	0.09	0.05	0.03	0.02	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.44
9000	0.32	0.12	0.07	0.04	0.04	0.03	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.66
10000	0.57	0.22	0.10	0.08	0.03	0.04	0.03	0.01	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.11
11000	0.98	0.42	0.19	0.12	0.08	0.05	0.03	0.02	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.92
12000	1.79	0.69	0.30	0.17	0.11	0.08	0.04	0.03	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.24
13000	2.55	1.07	0.51	0.29	0.21	0.12	0.07	0.05	0.02	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.93
14000	3.53	1.67	0.79	0.44	0.29	0.15	0.13	0.07	0.03	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.16
15000	4.16	2.14	1.25	0.74	0.41	0.23	0.14	0.07	0.04	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9.23
16000	4.03	2.65	1.60	0.90	0.65	0.31	0.18	0.11	0.05	0.03	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.57
17000	3.38	3.13	1.96	1.23	0.78	0.42	0.23	0.10	0.04	0.03	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	11.33
18000	2.49	3.24	2.33	1.39	0.86	0.46	0.28	0.11	0.05	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	11.27
19000	1.63	2.79	2.12	1.43	0.90	0.50	0.22	0.11	0.05	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9.82
20000	0.96	2.47	1.96	1.34	0.90	0.48	0.21	0.10	0.04	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	8.51
21000	0.49	1.79	1.62	1.15	0.75	0.37	0.19	0.07	0.04	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.49
22000	0.30	1.17	1.21	0.85	0.58	0.33	0.15	0.05	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.68
23000	0.13	0.82	0.82	0.68	0.45	0.21	0.10	0.03	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.28
24000	0.07	0.45	0.50	0.41	0.26	0.15	0.05	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.92
25000	0.04	0.24	0.27	0.25	0.19	0.09	0.03	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.12
26000	0.01	0.10	0.17	0.16	0.11	0.06	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.65
27000	0.01	0.05	0.09	0.07	0.05	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.30
28000	0.00	0.02	0.02	0.03	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.12
29000	0.00	0.01	0.01	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07
30000	0.00	0.00	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04
31000	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
32000	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
33000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
34000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
35000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
36000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
37000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
38000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
39000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
40000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
41000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
42000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
43000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
44000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
45000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
46000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
47000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
48000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
49000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
50000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL	28.07	25.60	18.13	11.92	7.79	4.17	2.18	1.02	0.46	0.22	0.11	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.00

Note: Calculated from DHIA data.