Economic Report ER77-6

Characteristics of Milk Production in Minnesota, 1967-1976 and Projections

by

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CHARACTERISTICS OF MILK PRODUCTION IN MINNESOTA, 1967-1976 AND PROJECTIONS

Wallace C. Hardie and Jerome W. Hammond*

INTRODUCTION

Milk production in Minnesota from 1967 to 1976 continued to be characterized by declines in dairy farm numbers, changes in technology, and an increasing share of total milk production meeting requirements for fluid use. This study measures and analyzes some of these changes -- particularly the changes in farm organization and techniques and the factors associated with the Grade B to Grade A shift in the state. Specific objectives of the study are:

(1) to examine the structure of dairy farming in Minnesota in terms of numbers, size, and regional distribution of farms,

(2) to describe the physical characteristics, sources of income, and human resources on Minnesota dairy farms,

(3) to identify the factors associated with Grade B to Grade A conversion, and

(4) to examine the direction and magnitude of structural and technological changes in the Minnesota dairy industry since 1967 and to make projections of future development.

Data for this study were obtained from regular statistical reports of the Minnesota Crop and Livestock Reporting Service in cooperation with the Minnesota Department of Agriculture, from other studies on milk production in the Midwest, and a survey of Minnesota dairy farmers conducted in July of 1976. The latter was similar to a survey of Minnesota dairy farmers conducted in 1967. 1/ Data were obtained from these surveys on farm size, milk production, production techniques, and operator characteristics.

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* Wallace C. Hardie is a research specialist and Jerome W. Hammond is a professor in the Department of Agricultural and Applied Economics, University of Minnesota.

1/ Results are reported in Boyd M. Buxton, "Labor Needs in Lake State Dairy Farming - 1967, 1975, and 1980," October 1970.

GENERAL CHARACTERISTICS OF MILK PRODUCTION IN MINNESOTA

Total Volume and Location of Milk Produced

Minnesota milk production declined almost 10 percent between 1967 and 1976 (Table 1). This occurred through declines in the number of dairy cows and dairy farms. The impact of these two changes was moderated to some extent by increased production per cow. The net decline in total production is attributable to several factors. First, other farm enterprises, including cash grain and beef cattle, appeared to be more profitable options to dairy farmers in many parts of the state. Second, nonfarm jobs continued to attract farmers who were small and unable to obtain capital for viable dairy operations.

The quality classification of Minnesota milk changed even more drastically than total production between 1967 and 1976. Only 18.7 percent of all milk received at plants was eligible for fluid use (Grade A) in 1967. By 1975, this had risen to more than 40 percent. Of the remainder, about 57 percent was marketed as Grade B milk and about 3 percent was fed to calves, consumed in the farm household, or marketed as cream.

Milk production remained concentrated in the "dairy belt" throughout the past 10 years. In 1975, 33 counties extending from the southeast to west central area accounted for 75 percent of Minnesota's total production of 8.9 billion pounds of milk (see Figure 1). In 1967, this same area contributed about 71 percent of the then total production of 10.2 billion pounds of milk. Between 1967 and 1975, milk production declined by almost 27 percent in the area outside the dairy belt, while milk production in the dairy belt declined by only 7.6 percent over the period.

Cow Numbers and Production Per Cow

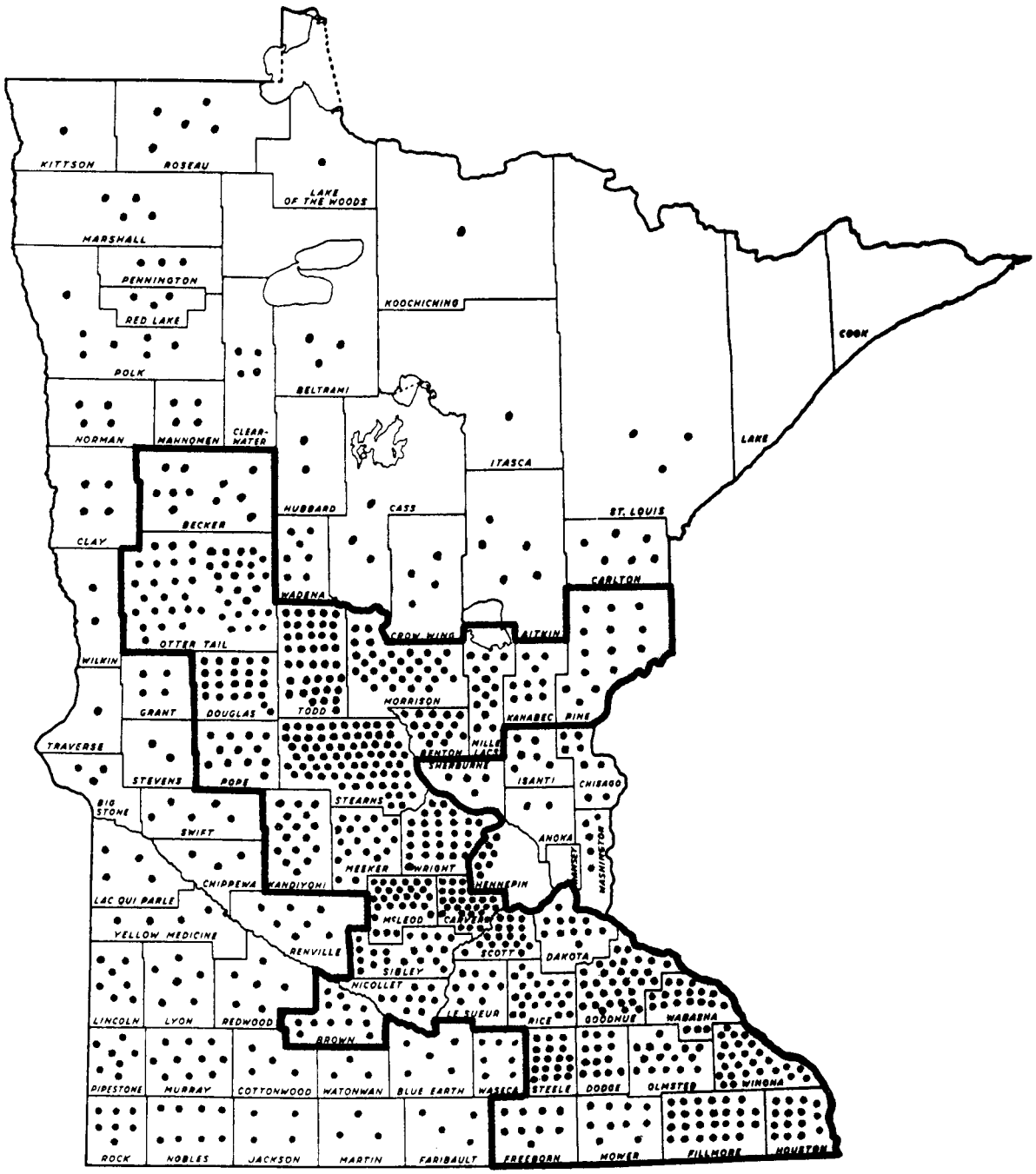
Between 1967 and 1976, the number of milk cows in the state declined from 1,084,000 to 878,000 head (Table 1), a decline of 19 percent. However, the decline was very rapid during the first half of the period and then it moderated substantially. If the current rate of decline continues, dairy cow numbers in Minnesota will be around 850,000 head in 1986.

Through improved feeding practices and the process of selecting higher producing cows, milk production per cow increased at an average annual rate of 1.6 percent from 1967 through 1972. Even though the long-term trend in production per cow is upward, high feed prices,

Table 1. Minnesota dairy production and marketing statistics, 1967-1976.

	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
Dairy farms (thousands)	62.0	56.0	51.0	46.0	44.0	41.0	38.0	36.0	34.0	31.0
Milk cows on farms (thousands)	1,084	1,036	976	949	942	932	911	890	884	878
Milk cows per farm	17.5	18.5	19.1	20.6	21.0	22.7	24.0	24.7	26.0	28.3
Milk production per cow (pounds)	9,446	9,866	9,966	10,154	10,210	10,279	10,177	10,542	10,120	10,523
Milk production per farm (1,000 pounds)	165	182	190	209	218	234	244	261	263	298
Total milk production (million pounds)	10,240	10,221	9,727	9,636	9,618	9,580	9,271	9,382	8,946	9,239
Price received by farmers per 100 pounds (dollars)	4.13	4.31	4.52	4.76	4.96	5.16	6.35	7.28	7.69	
Value of sales of milk and cream (million dollars)	411	430	429	449	468	486	578	682	687	

SOURCE: Minnesota Dairy Statistics, 1965-1974, Minnesota Crop and Livestock Reporting Service, SRS, U.S. Department of Agriculture, cooperating with Minnesota Department of Agriculture and Field Accounting and Statistics Division, January 1976; Minnesota Agricultural Statistics, 1967-1976, Minnesota Crop and Livestock Reporting Service, U.S. Department of Agriculture, Minnesota Department of Agriculture.



SOURCE: Minnesota Agricultural Statistics, 1976, Minnesota SRS, U.S. Department of Agriculture.

Figure 1. Milk production in Minnesota, 1975. (Each dot represents 10 million pounds of milk production.)

feed quality, and adverse weather can cause substantial variation in production per cow from one year to another. [2/] The dairyman's ability to adjust to changes in feed cost, availability, and quality is important in maintaining maximum profit per cow.

Farm Numbers and Production Per Farm

There were 29,520 farms selling milk or cream in Minnesota in November 1976. [3/] Of this total, 21,050 shipped manufacturing (Grade B) milk and 8,300 (28 percent) sold fluid eligible (Grade A) milk. The number of those shipping cream was negligible in all but the northern areas.

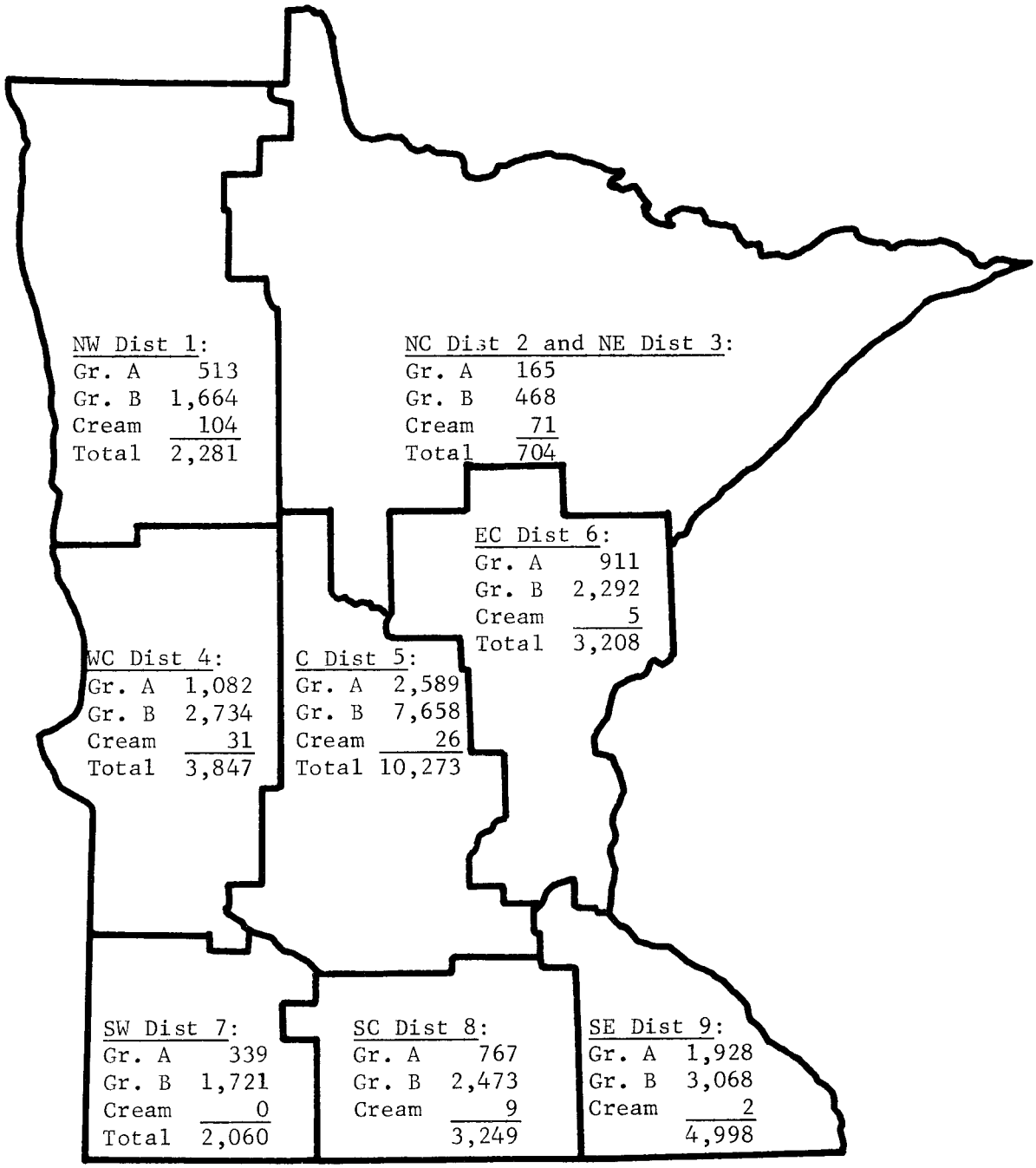
Both Grade B and Grade A milk farms are concentrated in the central and southeastern portions of the state. Heaviest concentration is in the central region. About one-third of all milk producers in the state are located in the area just west and northwest of the Twin Cities. Figure 2 shows the relative distribution of dairy farms in the state by grade of milk or cream sold. Note that the central region of the state contains twice as many dairy farms as the southeast, the next most important dairy region.

A considerable decrease in farms selling milk or cream occurred during the period 1967 through 1976, from 56,730 herds to 30,620 herds. Nationally, milk cow farms declined from 898,250 to 421,160 over the period. The total number of Minnesota dairy farms decreased by 46 percent over this period or an annual rate of about 6.62 percent, while the national decline was 53 percent or an annual rate of 8.05 percent. The decrease in Minnesota was somewhat more rapid during the early years, 6.94 percent through 1972 and 6.23 percent for the period 1972-1976.

The decline in dairy farm numbers is a continuation of the long-term exit (since 1950 at least) of small, part-time dairymen, or inefficient dairy enterprises. The exit occurs because of greater returns for the operator in other enterprises, both farm and nonfarm. The 7-day-a-week work requirement that is common to most dairy operations has undoubtedly caused some dairymen to shift to other less demanding enterprises. This may occur even when monetary returns from other enterprises are less than in dairying.

2/ It is rather interesting to note that during the 1976-77 crop year when feed was short in Minnesota and hay prices were exceedingly high, milk production per cow increased.

3/ Minnesota Department of Agriculture, Division of Field Accounting, preliminary estimate.



SOURCE: "June Dairy Report," Minnesota Department of Agriculture, Minnesota SRS, U.S. Department of Agriculture.

Figure 2. Number of dairy farms in Minnesota by grade, preliminary, June 1976.

The decline in farm numbers occurred entirely among Grade B and cream farms (Figure 3 and Appendix Table 3). Grade B farms declined 51 percent from 1967 to 1972. Cream producers declined 96 percent. Grade A farms increased by 71 percent. Most of the Grade A increase reflected a shift of Grade B farms to Grade A status.

Average annual milk production per farm in Minnesota rose from 165,000 pounds in 1967 to 298,000 pounds in 1976, an increase of 45 percent (Table 1). The dairy belt accounted for the highest average farm production. The lowest average milk production per farm occurred in the northern areas of the state. Grade A shipments per farm averaged almost twice the amount of Grade B shipments on a statewide basis in 1974, 450,400 for Grade A farms and 226,900 for Grade B farms.

Herd Size and Projections

Average herd size increased from 17.5 cows per farm in 1967 to 28.3 in 1976 (Table 1). Generally, Minnesota dairy farms are small in comparison with those of other important milk producing states. Minnesota ranked twenty-second among all states in average herd size in 1974. Of the three other major dairy producing states, Wisconsin averaged 33.4 cows per herd; New York averaged 41.1 cows per herd; and California averaged 135.1 cows per herd in 1974.

A classification of farms by herd size indicates that 61 percent of milk shippers in Minnesota had less than 30 milking cows in 1976. The dairy belt region had larger than average herd sizes as indicated in Figure 4. But the southeast region of the state had the largest average herd size in 1976, 30.6 cows per herd.

The shift in the distribution of milk producers toward larger herd sizes is shown in Table 2. The small herds of 19 cows or less declined from 60 percent of all herds in 1967 to 35 percent of all herds in 1976. Farms of 30-99 cows showed the largest increase, from 15 percent of all herds in 1967 to 38 percent in 1976. There are only 200 herds in Minnesota that exceed 100 cows and since 1972 these numbers have not changed.

Projections of the number and size distribution of dairy herds were made for each biennium, 1978 through 1986. The method used for projection is known as the Markov Process. 4/ The projections indicate an average annual decline in dairy herds of 4.6 percent (Table 2 and Figure 5). The rate of decline is somewhat more rapid for the first

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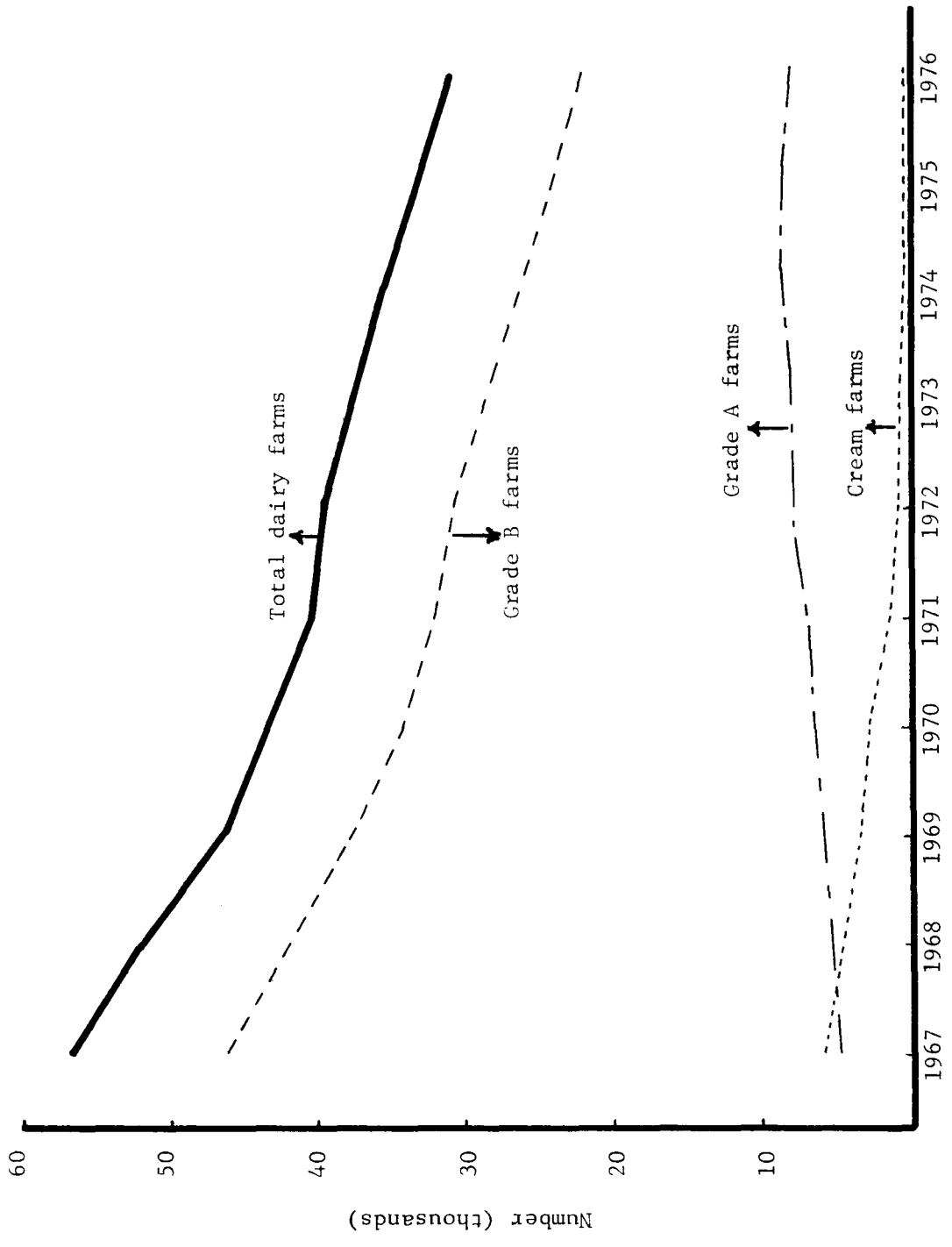
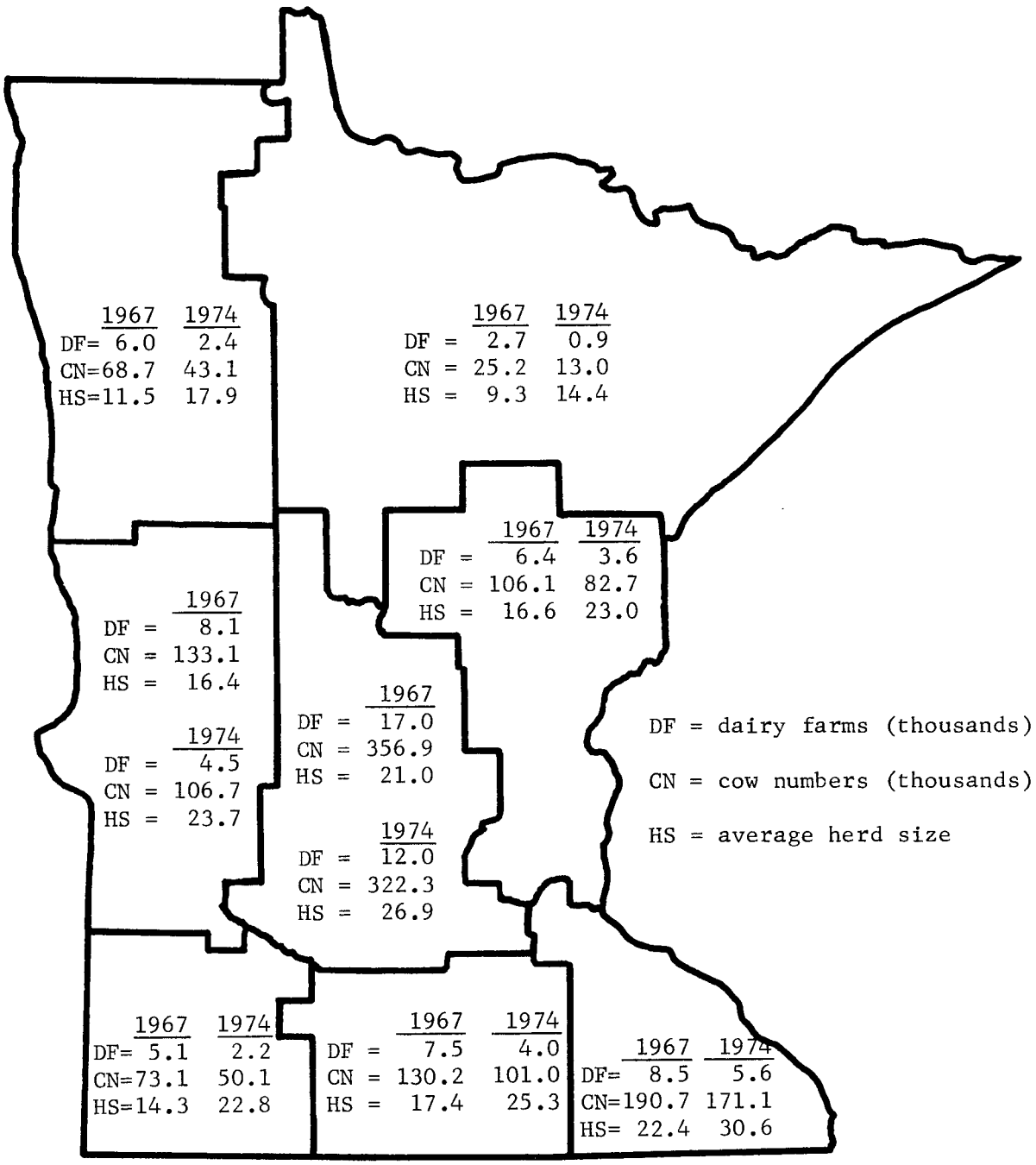
4/ The underlying probabilities for the projections of changes in the size distribution of farms are calculated from the past history of movement among size categories. It assumes that the economic and technical factors that determine farm size operate in a probabilistic manner and will continue in the future.



SOURCE: "June Dairy Report," Minnesota Department of Agriculture, Minnesota SRS, U.S. Department of Agriculture.

Figure 3. Number of farms selling Grade A milk, Grade B milk, and cream at mid-year, Minnesota, 1967-1976.



SOURCE: Minnesota Dairy Statistics, 1965-1974, Minnesota Agricultural Statistics - 1968, Minnesota SRS, U.S. Department of Agriculture.

Figure 4. Dairy farm numbers, cow numbers, and average herd sizes by crop reporting districts, 1967 and 1974.

Table 2. Number of farms by size of dairy herd, 1967-1976, projections to 1986.

Year	Herd size				
	1-19	20-29	30-99	100+	Total
1967	34,300	14,100	8,300	*	56,700
1968	31,200	12,900	7,700	*	51,800
1970	20,500	11,400	11,500	*	43,400
1972	15,500	11,000	12,900	200	39,600
1974	13,000	9,600	12,500	200	35,300
1976	10,800	8,100	11,600	200	30,700
1978	6,000	6,500	12,600	200	25,300
1980	4,500	5,800	12,900	200	23,400
1982	3,300	5,200	13,000	200	21,700
1984	2,500	4,600	13,000	200	20,300
1986	1,900	4,100	13,000	200	19,200

SOURCE: Minnesota State Farm census data adjusted by the Minnesota Department of Agriculture estimates of farms selling milk or cream.

* Less than one percent.

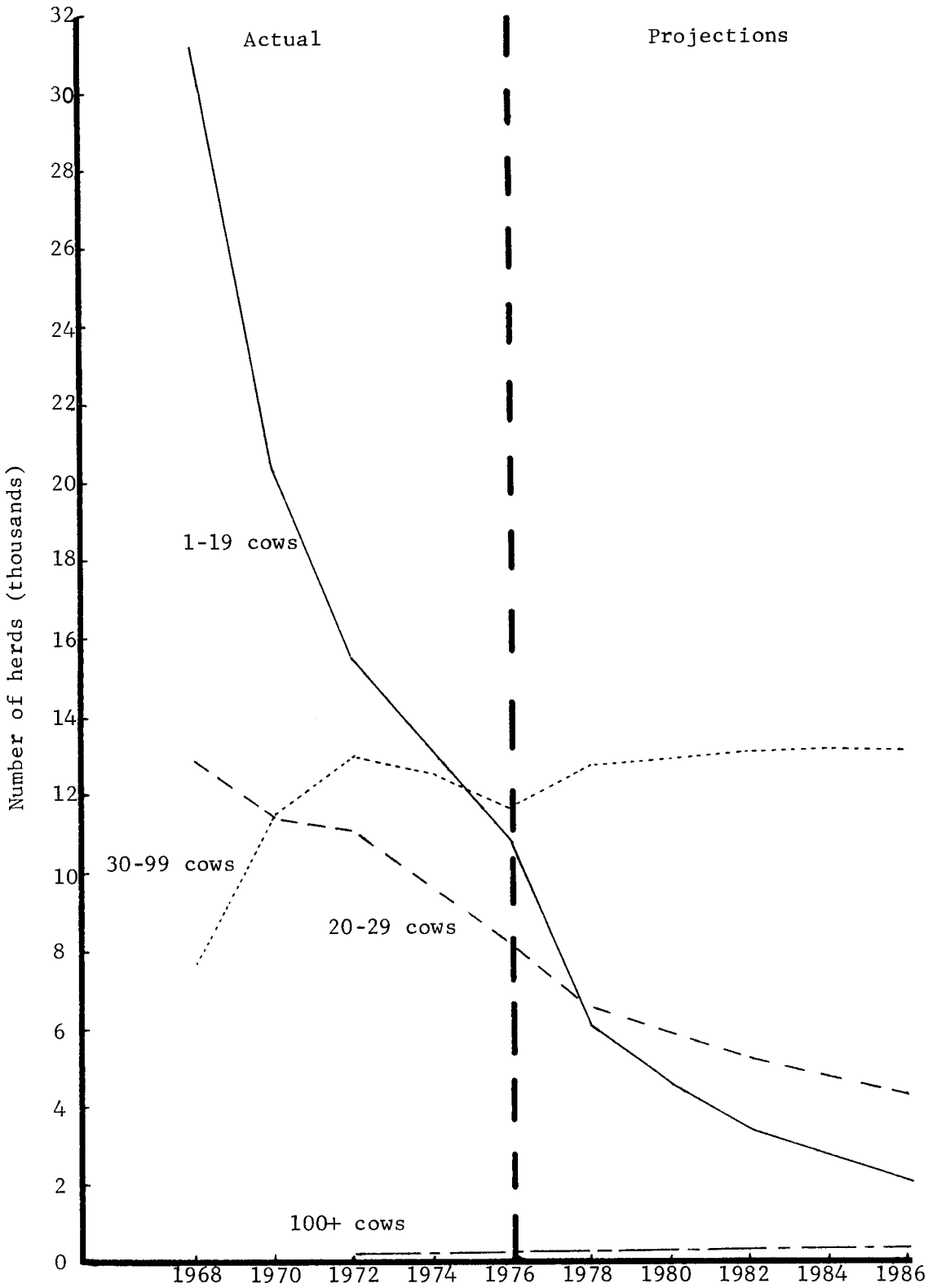


Figure 5. Number and herd size distribution of farms reporting milk cows in Minnesota, 1968-1976 and projections to 1986.

half of the period than the second. The number of farms with less than 20 cows will decrease steadily, and the number of herds of 20-29 cows will also decline through 1986. Herds having 30-99 cows which now account for one-third of all herds will account for two-thirds of all herds. Since many of the economies of size in milk production are achieved in this size range, we do not now expect much growth in herd size beyond this size group. The lack of projected growth in numbers of herds (100 and above) tends to support this conclusion.

In total, the number of farms selling milk and cream in Minnesota is projected to decrease from about 29,500 in 1976 to about 19,200 in 1986, a decline of 10,300 herds. Unfortunately, the technique does not tell us the average size of herd within each size category. Therefore, it is not possible to determine the number of cows represented in the new distributions. As indicated in a preceding section, however, total cow numbers are likely to be about 850,000 in 1976.

CHANGES IN MINNESOTA MILK PRODUCTION PRACTICES

The preceding tendencies to expand herd size, to convert from Grade B to Grade A production, or to move out of the dairy business have been associated with changes in production practices and techniques on dairy farms. The following section describes specific characteristics of Minnesota dairy farms in 1976, the changes which have occurred in milk production practices on farms in the last decade, the differences which exist between Grade A and Grade B milk farms, and the conditions that lead to or are conducive to Grade A milk production.

Much of the description that follows is based on two surveys of dairy farms in the Upper Midwest. During May and June of 1968, a questionnaire on milk production practices was mailed to a random sample of Minnesota farms shipping milk. 5/ Completed or partially completed questionnaires were received from 536 Minnesota dairy farmers. In June of 1976, a similar questionnaire dealing with operator characteristics and milk production practices was mailed to another random sample of Minnesota dairy farmers. Completed or partially completed questionnaires were received from 205 dairy farmers. The information obtained in the later survey was based on farm situations as of June 1, 1976.

These surveys included only dairy producers shipping milk to commercial buyers. Farms which shipped cream or used milk for home consumption only were excluded.

A comparison of the results of the two surveys illustrates the transition in dairy farm characteristics that occurred over the 10-year period. Comments on particular problems encountered in the surveys and probable biases in results are discussed in the text or in footnotes to the tables. The number of farms included for each item of information in the tables that follow is shown in parenthesis under the item.

Sample Farm Size

Data furnished by the sample dairymen in 1967 and 1976 also indicate a major increase in the number of milk cows per farm, total milk production per farm, and average production per cow over the period (Table 3). Milk production per sample farm increased by about 57 percent during the time period compared to 80 percent for all dairy farms in the state. Note that for both years, the average size of respondent farms was larger than the actual state average (see Table 1). Further, the average production per cow was much larger than the state

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5/ Boyd M. Buxton, "Labor Needs in Lake State Dairy Farming - 1967, 1975, and 1980," Economic Study Report No. S70-4, October 1970.

average. The figures indicate that the larger, more efficient operators are more inclined to respond to surveys. Thus, in the description that follows, some bias in the results is to be expected. Nevertheless, the changes that occurred between 1967 and 1976 should be indicative of general trends in the total dairy industry.

Table 3. Average number of cows per farm, average milk production per farm, and average production per cow, Minnesota dairy survey, 1967 and 1976. (Based on number of farms shown in parentheses.)

	1967	1976
Average number of cows	22.9 (518)	32.0 (204)
Average milk production per farm (pounds)	265,000 (385)	415,600 (92)
Average milk production per cow (pounds)	11,570	12,990

The increase in average milk production per farm has not been accompanied by an increase in average cropland acres operated according to survey results (Table 4). In fact, average acres of cropland for sample farms actually declined over the period. Why this occurred could not be determined from the questionnaire. One hypothesis is that increased specialization has taken place in dairy agriculture just as it has in other farm enterprises in the state. Those farmers with large acreages of cropland have moved entirely into cash crops. Those diversified dairy-crop farms with limited cropland have specialized in and intensified the dairy operation.

Table 4. Average acreage per dairy farm, Minnesota dairy survey, 1967 and 1976. a/

	1967		1976
Cropland owned	154 (489)		156 (192)
Cropland rented	140 (203)		125 (89)
Improved pasture	38 (306)	owned:	56 (154)
		rented:	56 (35)

a/ Figures are average acres of only those farms reporting each and not an average of all farms in the survey.

Technological Changes

Data on four aspects of technology in milk production were obtained from the survey: (1) type of housing, (2) mechanization, (3) feeding and nutrition, and (4) breeding. Changes since 1967 have been moderate to major.

Type of Housing. New types of dairy housing systems have received considerable publicity in trade journals and they have been widely adopted in many parts of the U.S. However, the conventional stanchion system accounts for the largest share of housing systems in Minnesota -- almost 90 percent of the herds with only a slight decrease in the percentage since 1967 (Table 5). Grade A farms account for a larger share of the alternative housing systems than Grade B farms. The cold free stall is the most popular alternative. It accounts for more than 18 percent of Grade A herd housing systems.

Table 5. Type of housing for dairy herds, Minnesota, 1967 and 1976.

Types of housing	Percentage of farms a/			
	1967	1976		
		Grade A	Grade B	Total
Stanchion	90.9	81.1	93.0	88.6
Stanchion-rotated use	5.0	0.0	2.3	1.5
Loose-conventional	3.3	1.4	1.6	1.5
Cold free stall	0.8	13.5	2.3	6.4
Warm enclosed free stall	0.6	4.1	0.8	2.0
Total	100.6	100.1	100.0	100.0
	(525)	(74)	(128)	(202)

a/ Percentage of farms adds to more than 100 because some farms reported more than one type of housing.

No major changes overall in type of housing appear to have developed since 1967. The lack of a large shift is probably due to the relatively small dairy herd size in Minnesota. For small herds, stanchion barns are very competitive with alternatives. Management specialists report that until herd size reaches 60-70 cows, manure and feed handling in conventional stanchion barns present no special problems. Thus, the existing conventional stanchion barns are likely to be the main dairy housing system in Minnesota for the foreseeable future.

Considerable differences exist in the condition of dairy buildings and equipment. Based on the farmer's own evaluation of condition, 7 percent of Grade B farm buildings and equipment were judged to be in excellent condition compared with 44 percent for Grade A farms. Thirty-six percent of Grade B buildings and equipment were judged to be only fair in condition. One would expect the largest number of exits from dairying to occur from this group of farms.

Mechanization. To reduce some of the more difficult labor requirements on dairy farms, to permit operation of larger units, and to adjust to rising labor rates and tightening of the farm labor supply, increased mechanization has occurred on dairy farms. Adoption of labor-saving devices has occurred in all milk production activities -- feed production, feeding, milking, and manure handling.

According to the survey, 88 percent of Grade A producers and 83.6 percent of Grade B producers fed corn silage to their dairy herds in 1976. Mechanization in corn silage feeding has progressed rapidly in the last 10 years. Fifty-nine percent of farms with silos unloaded them by hand in 1967. This had fallen to 35 percent in 1976 (Table 6). Grade A farms are more mechanized in this respect than Grade B farms. More than 50 percent of the latter still unload and distribute silage by hand. The use of a single ration where silage and concentrates are mixed together in a complete feed facilitates the mechanization of the feeding operation.

Table 6. Method of storing and feeding corn silage, Minnesota dairy survey, 1967 and 1976.

Method	Percentage of farms [a]			
	1967	1976		
		Grade A	Grade B	Total
Upright silo, hand unloaded and distributed with cart	59.0	6.1	51.9	35.0
Upright silo, mechanically unloaded and distributed with cart	29.9	42.4	23.6	30.6
Upright silo, mechanical unloader and feed bunk	5.3	45.5	11.3	24.0
Bunker silo	16.7	6.1	13.2	10.6

a/ Percentage adds to more than 100 because some farms reported more than one method.

Bulk tank milk storage and cooling systems increased from 40.5 percent of dairy farms selling milk in 1967 to 69.4 percent of these farms in 1976 (Table 7). Since Grade A milk is handled in bulk form only, all Grade A farms have bulk tanks. The percentage of Grade B farms with bulk tanks increased from 34.2 percent in 1967 to 57.9 percent in 1976. Although the percentage of Grade B farms with bulk tanks increased over this period, actual numbers of Grade B farms with bulk tanks actually decreased. The large decline in Grade B farms resulted in a net decline in both can and bulk operators. Obviously, the rate of decline is much greater for the can operations.

Table 7. Method of storing milk, Minnesota, 1967 and 1976.

Method	Percentage of farms selling milk a/					
	1967			1976		
	Grade A	Grade B	Total	Grade A	Grade B	Total
Bulk tank	100.0	34.2	40.5	100.0	57.9	69.4
Cans	0.0	65.8	59.5	0.0	42.1	30.6
Total	100.0	100.0	100.0	100.0	100.0	100.0

SOURCE: "June Dairy Report," Minnesota Department of Agriculture, Minnesota Statistical Reporting Service, U.S. Department of Agriculture.

a/ Sample percentages were larger than published estimates. About 46 percent of sample farms reported shipping milk bulk in 1967 and 78 percent in 1976.

One of the most significant changes in dairy production technology is the adoption of pipeline milking systems. With this system, milk is transferred directly from the cow milking unit to storage via a milk line and vacuum system. The percentage of farmers using pipeline milkers increased from 4.2 to 34.6 during the 10-year period according to survey results (Table 8). Here also there was a considerable difference in the adoption between Grade A and Grade B farmers, probably due to unwillingness on the Grade B operator's part to install a new expensive system into rather old existing facilities.

Table 8. Methods of conveying milk to storage, Minnesota dairy survey, 1967 and 1976.

Method	Percentage of farms			
	1967	1976		
		Grade A	Grade B	Total
Pipeline	4.2	66.7	15.7	34.6
Milk transfer	10.4	20.0	18.9	19.3
Carry by hand	85.4	13.3	65.4	46.1
	100.0	100.0	100.0	100.0
	(509)	(75)	(127)	(202)

Parlor type milking facilities were used by 10 percent of all farms in the 1976 survey. One-fifth of the Grade A respondents used milking parlors with the herringbone type the most popular (Table 9). Less than 4 percent of Grade B farmers reported using milking parlors as an alternative to stanchion milking.

Table 9. Percentage of farms with milking parlors and type of milking parlor, Minnesota dairy survey, 1967 and 1976.

	Percentage of farms			
	1967	1976		
		Grade A	Grade B	Total
Farms with milking parlors	2.5	20.0	3.9	9.9
	(536)	(75)	(129)	(204)
Farms with parlors (by type of parlor): [a]				
Herringbone	20.0			44.5
Walk through	31.0			22.2
Side opening	40.0			22.2
Other	9.0			11.1
	100.0			100.0
	(15)			(18)

a/ Percentages based on small group of farmers that reported milking parlors.

With the milking parlor system, cows are brought to the operator in groups and placed in elevated stalls for easier access to the udder. A milkroom for the bulk tank and milking equipment is usually located adjacent to the parlor. With milking parlors, the cows are usually fed some concentrate during the milking operation. Several types of parlors are used.

The herringbone milking parlor is one in which two groups of four to eight cows are arranged in a relatively short linear space by angling cows about 30 degrees into the central operator area. 6/ Cows are brought into one side of the parlor and a milking unit is placed on each cow. While this one group of cows is being milked, a second group is brought into the opposite side of the parlor and prepared for milking.

In the walk through and side opening parlors, the arrangement of the stalls allows more operator access to the cows. Individual cow control is the advantage of these systems, whereas the herringbone system usually offers faster milking.

Mechanized manure handling has reduced labor requirements on many dairy farms since 1967. Only 17 percent used hand loading of manure in 1976 compared to 50 percent in 1967 (Table 10). About 25 percent of Grade B farmers still remove manure by hand loading means. Gutter cleaning systems have been and are the most popular manure handling technique. Tractor loading and litter carriers have decreased in importance. Liquid systems were used on only 6.7 percent of the Grade A farms and on none of the Grade B farms.

Feeding and Nutrition. The maintenance of proper feed rations has become a more important consideration to Minnesota dairymen as they seek to achieve optimum milk production in their herds. According to records obtained for herds participating in Minnesota's Dairy Herd Improvement Association (DHIA), feeding rates of hay and average days on pasture per cow have decreased. The decline in hay feeding has been offset by increased silage use. The amount of silage fed per cow increased from 11,200 pounds in 1967 to 13,000 pounds in 1975 (Table 11). Concentrate feeding on a per cow basis remained unchanged from 1967 through 1975.

6/ Economies of Size in Minnesota Dairy Farming, Station Bulletin 488, Agricultural Experiment Station, University of Minnesota, 1968.

Table 10. Method of manure disposal, Minnesota dairy survey, 1967 and 1976.

Method	Percentage of farms [a]			
	1967	1976		
		Grade A	Grade B	Total
Hand loading into spreader or storage	50.5	2.7	24.8	16.6
Gutter cleaner	30.8	76.0	52.0	60.8
Litter carrier	15.9	1.3	11.6	7.8
Tractor loader	22.0	13.3	11.6	12.2
Liquid manure system	0.0	6.7	0.0	4.2
	119.2	100.0	100.0	101.6
	(533)	(75)	(129)	(204)

a/ Percentages add to more than 100 because some farms reported more than one method.

Table 11. Changes in feeding practices and costs, Minnesota DHIA herds, 1967 and 1975.

Item	1967	1975
Average amount of silage per cow (pounds)	11,200	13,000
Average amount of hay per cow (pounds)	4,700	3,900
Average amount concentrates per cow (pounds)	4,900	4,900
Average days on pasture	70	39
Average roughage-pasture cost per cow	$90.00	$301.00
Average concentrates cost per cow	$108.00	$266.00
Average total feed cost per cow	$198.00	$567.00
Average feed cost per hundredweight of milk	$1.59	$4.28

SOURCE: Annual Summaries, 1967 and 1975, DHIA, Agricultural Extension Service, University of Minnesota.

There appears to be considerable emphasis in recent years on the development of rations for dairy cattle that (1) use feeds which lend themselves to reduced labor and individual cow attention and (2) minimize costs. Silage is particularly suited to these objectives in that both harvesting and feeding can be almost completely mechanized. Furthermore, it is a good source of energy and protein.

For almost all dairy farms, part of the feed requirements must be purchased; 98 percent of the farms in the 1967 survey purchased feed. The survey indicated that, on the average, 20 percent of total annual feed requirements were purchased. Though corn, oats, and hay occasionally may be purchased, the purchases are most likely to have been protein supplements such as soybean meal.

The use of least-cost rations is important because feed costs have risen sharply in the last 10 years. In 1967, average feed costs per hundredweight of milk produced by Minnesota DHIA herds were approximately $1.59 (Table 11). By 1975, feed costs had risen to about $4.28 per hundredweight of milk. In comparison to average price of milk received, feed costs increased from 38.5 percent in 1967 to 49.3 percent in 1975.

Improvements through Breeding. Higher milk producing animals have been achieved through selective breeding processes. Much of this has been accomplished because of artificial breeding programs which enable all producers to utilize proven sires to upgrade herds. Artificial insemination for dairy cows and heifers first began to be widely used during the 1940's and has increased continuously since that time. In 1947, average milk production per cow in Minnesota was 5,500 pounds. By breeding, selection, and improved feeding, milk production per cow had risen to 10,523 in 1976. Further, there are many producers in the state that have herd average production per cow in the range of 15,000 to 20,000 pounds annually.

Between 1966 and 1974, milk cows which were bred artificially in Minnesota increased from 55 to 70 percent (Table 12). The trend indicates that we are rapidly moving to a situation where almost all dairy cows will be artificially bred. According to the 1976 survey, 88 percent of Grade A producers and 68.5 percent of Grade B producers utilized artificial insemination.

Table 12. Total number of dairy cows and percentage bred artificially, Minnesota, 1966-1974.

Year	Total dairy cow numbers[a/]	Cows bred artificially[b/]	Percentage of cows bred artificially
	(thousands)	(thousands)	
1966	1,144	627	54.8
1967	1,084	612	56.5
1968	1,036	595	57.4
1969	976	592	60.7
1970	949	588	62.0
1971	942	589*	62.5
1972	932	632*	67.8
1973	911	626*	68.7
1974	890	625*	70.2

* Estimated.

a/ From Minnesota Dairy Statistics: 1965-1974, excludes heifers not yet fresh.

b/ From Artificial Breeding Report, ARS, Volumes 43-47.

Labor and Management

Hired Labor. In the 1976 survey, 44 percent of Minnesota Grade B producers hired farm labor. The duration of outside help averaged nine weeks per year. Grade A producers hired more labor on the average than Grade B producers. Fifty-two percent of the Grade A producers surveyed used outside help. The average amount of labor hired on these farms was 16.7 weeks per year.

The number of weeks of hired labor per farm was directly related to herd size. Smaller Grade B producers (less than 30 cows) reported employed labor for an average of five and one-half weeks of the year, while larger Grade B producers (30 cows and over) averaged 13 weeks of hired labor. Grade A operators with smaller herds (less than 30 cows) averaged 14.4 weeks of hired labor, while those with larger herds averaged 17.3 weeks per year.

Age of Operators. The average age of Grade B milk producers in the 1976 survey was 49 years and the average age of Grade A producers was 47 years. The age of operator appears to be inversely associated with the number of cows milked. Grade B producers with smaller herds (less than 30 cows) averaged 50 years of age; larger Grade B producers average 48 years of age. This relationship was stronger in the case of Grade A producers. Grade A producers with less than 30 cows averaged 53 years and those with 30 cows and over averaged 46 years of age.

Experience of Operators. Minnesota Grade B producers averaged 23 years of experience in operating a dairy farm. Only 15 percent of Grade B producers had 10 years or less of farming experience. Grade B farmers with larger herds (30 cows and over) had, on the average, three years less farming experience than operators with smaller herd sizes.

The Grade A milk producers in the survey averaged 21 years of experience in farming. About 22 percent of Grade A producers had 10 years or less of farming experience. Grade A producers with herd sizes of 30 or more cows averaged two years less farming experience than those with smaller herd sizes.

Education of Operators. Grade B producers responding to the survey averaged almost 10 years of formal education. Forty-six percent had eight or less years of schooling; 42 percent had a high school education or more. The number of years of schooling was directly related to herd size. Grade B producers with eight or less years of schooling averaged 26 cows and those with 12 or more years of formal education averaged 32 cows per herd.

Producers of Grade A milk averaged 11 years of formal education -- slightly more than Grade B shippers, according to survey results. Twenty-eight percent had eight or less years of schooling and 69 percent had a high school education or more. Unlike the Grade B producer situation where years of formal education were related to herd size, there was essentially no relationship between education and herd size among Grade A producers.

Planned Adjustments

Operators were asked on the questionnaire about adjustments which they planned to make. Their responses imply continuing adjustments within the state's dairy industry. However, for both Grade A and Grade B operations, a substantial share of the producers are planning no changes in herd size -- 61 percent for Grade A and 50 percent for Grade B (Table 13). A large number of producers planned to dispose of all cows in the next five years -- 17 percent for Grade A and 31 percent for Grade B or 25.7 percent for all farms in the sample. The rate of decline implied by this response is similar to the decline projected earlier. The previous projections indicated a 4.6 percent annual decline for the next five years (1977-1982), while the respondents' planned adjustment indicates an annual decline of 5.1 percent.

Table 13. Future plans of dairy farmers, Minnesota dairy survey, 1976.

Alternatives	Percentage of farms		
	Grade A	Grade B	Total
Keep the same number of milk cows	61.3	49.6	53.9
Dispose of all milk cows within five years	17.3	30.7	25.7
Increase the number of milk cows	18.7	11.0	13.9
Decrease the number of milk cows	2.7	8.7	6.5
	100.0	100.0	100.0
	(75)	(127)	(202)

Comparison of characteristics of farmers planning to leave dairying and those remaining illustrates some important differences (see Table 14). Farmers with plans to leave dairying averaged 27.8 cows per herd compared with 40.9 cows for those planning to continue. Family labor appears to be related to the decision. Only 15.1 hours of labor per week were contributed by the family for those planning to leave as compared with 21.5 hours for those planning to continue. Age of operator, obviously a consideration in plans, averaged 52.5 years for planned exits and 47.4 years for those planning to remain. Potential for other income is also greater for those planning to exit.

Sources of Income on Dairy Farms

Minnesota dairy producers derive their total income from a variety of sources. The sample dairy farmers responding indicated that almost 70 percent of their total annual cash receipts came from the sale of milk (Table 15). The sale of livestock accounted for about 20 percent of cash receipts and the remainder was derived from the sale of crops and off-farm employment.

Grade B producers received approximately 67 percent of their total cash receipts from the sale of milk. A slightly higher degree of reliance on the milk enterprise was indicated among Grade B producers in the central district (72 percent of total cash receipts). The dependence on Grade B milk sales as a source of income rose directly with herd size. Smaller producers (up to 29 cows) received an average of 61 percent of their cash receipts from milk sales; producers with herd sizes of 30 cows or more, 76 percent.

Table 14. Characteristics of dairy farmers according to future plans, Minnesota dairy survey, 1976.

	Average of farmers planning to leave dairying within five years	Average of farmers planning to continue in the dairy industry indefinitely
Number of cows and heifers over two years old*	27.8	40.9
Age of operator*	52.5	47.4
Family labor hours contributed per week**	15.1	21.5
Percentage of total cash receipts from crop sales** ...	13.1	6.5
Percentage of total cash receipts from milk sales* ...	56.6	73.1
Percentage of total cash receipts from off-farm work***	8.4	2.8

* Means are statistically different with 99 percent confidence.
** Means are statistically different with 95 percent confidence.
*** Means are statistically different with 90 percent confidence.

Table 15. Sources of income on dairy farms, Minnesota dairy survey, 1976.

Item	Percentage
Crop income	8.2
Milk income	68.5
Livestock income	18.6
Off-farm income	4.2
Other	0.5
	100.0

Grade A milk producers had a higher dependency on milk sales as a source of income, 74 percent of total cash receipts from their milking enterprise. A positive relationship was observed between herd size and the level of specialization in dairying.

Generally, Minnesota milk producers receive a fairly high proportion of their income from the sale of livestock. The 1976 survey indicated that for both Grade B and Grade A producers about 38 percent derived one-fourth or more of their cash receipts from livestock sales. This percentage probably consists largely of sales of cull dairy cows and dairy calves. Few dairy farmers raise both beef cows and dairy cows. However, it is a common practice with the use of artificial insemination to breed some dairy cows to beef breeds. Feeding and finishing these steers and heifers as a sideline is common on many dairy farms.

The production of cash crops was not an important source of revenue for most of the dairy farmers. Only 37 percent of the Grade B producers reported crop sales amounting to one-tenth or more of total cash receipts. Sales of crops accounted for an even lower proportion of cash receipts among Grade A producers. Twenty-seven percent of Grade A respondents derived one-tenth or more of total cash receipts from crop sales.

The degree of dependence on off-farm employment was low among both Grade A and Grade B milk shippers. For all dairy farms, only 4.2 percent of their income was from nonfarm sources. Only 14 percent of those surveyed reported one-tenth or more of their cash receipts from this source. Also, as herd size increased, the proportion of cash receipts from off-farm employment declined.

ANALYSIS OF GRADE B TO GRADE A CONVERSION

Limits on Conversion

The shift of Minnesota and Wisconsin dairy farms from Grade B to Grade A status has many implications for the dairy industry. It is particularly important for the federal pricing program for milk under marketing orders. Currently, the Grade B milk price in Minnesota and Wisconsin is the principle mechanism for fixing the class prices for milk under marketing orders. If and when Grade B milk ceases to be an economically significant part of the dairy industry, an alternative mechanism of price setting in federal orders will be required. How rapidly will the shift from Grade B to Grade A occur, or will complete conversion occur in the near future? The ability to make predictions about the shift requires an analysis of those factors which induce the shift, i.e. those factors that affect the farm operator's incentives, willingness, and ability to convert the dairy enterprise from Grade B to Grade A. The following is an analysis of the data from our Minnesota survey that is related or possibly related to the adjustment.

According to 1976 survey results, 76 percent of Grade A respondents indicated that they had produced Grade B milk at one time but had converted to Grade A production. Only 17 percent of Grade B respondents indicated that they were presently considering shifting to Grade A.

To determine those factors that limit Grade B to Grade A conversion, we asked Grade B dairymen why they had not shifted to Grade A production. One or more of four major reasons were given.

(1) A large proportion (40 percent) indicated that they felt constrained by the high investment cost of additional facilities and equipment needed to meet the requirements imposed by the state for Grade A milk production. Grade B requirements are less stringent. Most of the requirements are specified in the Minnesota Milkhouse Law of 1969 which requires that Grade B farmers with bulk tanks meet specific requirements which pertain only to the separate building or room where the bulk tank is located. Standards for Grade A production require standards for farm water supply, barn construction, barnyard drainage, doors, access, lighting, and ventilation of dairy buildings.

(2) An obvious reason why more Grade B farmers do not shift to Grade A is the lack of a wide enough price differential between the two grades. This reason was indicated by 18 percent of the respondents in our survey. Between 1967 and 1976, prices received by Minnesota dairymen for milk with 3.5 percent butterfat increased from $4.37 to $9.05 per hundredweight for Grade A milk and from $4.00 to $8.36 per hundredweight for Grade B milk (see Table 16 and Figure 6).

Table 16. Minnesota average 3.5 percent price for Grade A and Grade B milk, 1960-1976. [a/]

Year	Grade A	Grade B	Difference	Difference deflated by index of prices paid by farmers [b/] (1967 = 100)
1960	$3.69	$3.07	.62	.67
1961	3.73	3.29	.44	.47
1962	3.70	3.17	.53	.56
1963	3.60	3.13	.47	.49
1964	3.63	3.19	.44	.47
1965	3.73	3.29	.44	.46
1966	4.18	3.78	.40	.40
1967	4.37	4.00	.37	.37
1968	4.60	4.18	.42	.41
1969	4.81	4.35	.46	.43
1970	5.04	4.57	.47	.43
1971	5.18	4.75	.43	.37
1972	5.36	4.93	.43	.35
1973	6.54	6.12	.42	.30
1974	7.57	6.98	.59	.37
1975	7.83	7.41	.42	.24
1976	9.05	8.36	.69	NA

a/ Minnesota Agricultural Statistics, Annual, Minnesota Statistical Reporting Service, USDA.

b/ Agricultural Statistics, 1976, USDA, prices paid for all commodities used for production, p. 457.

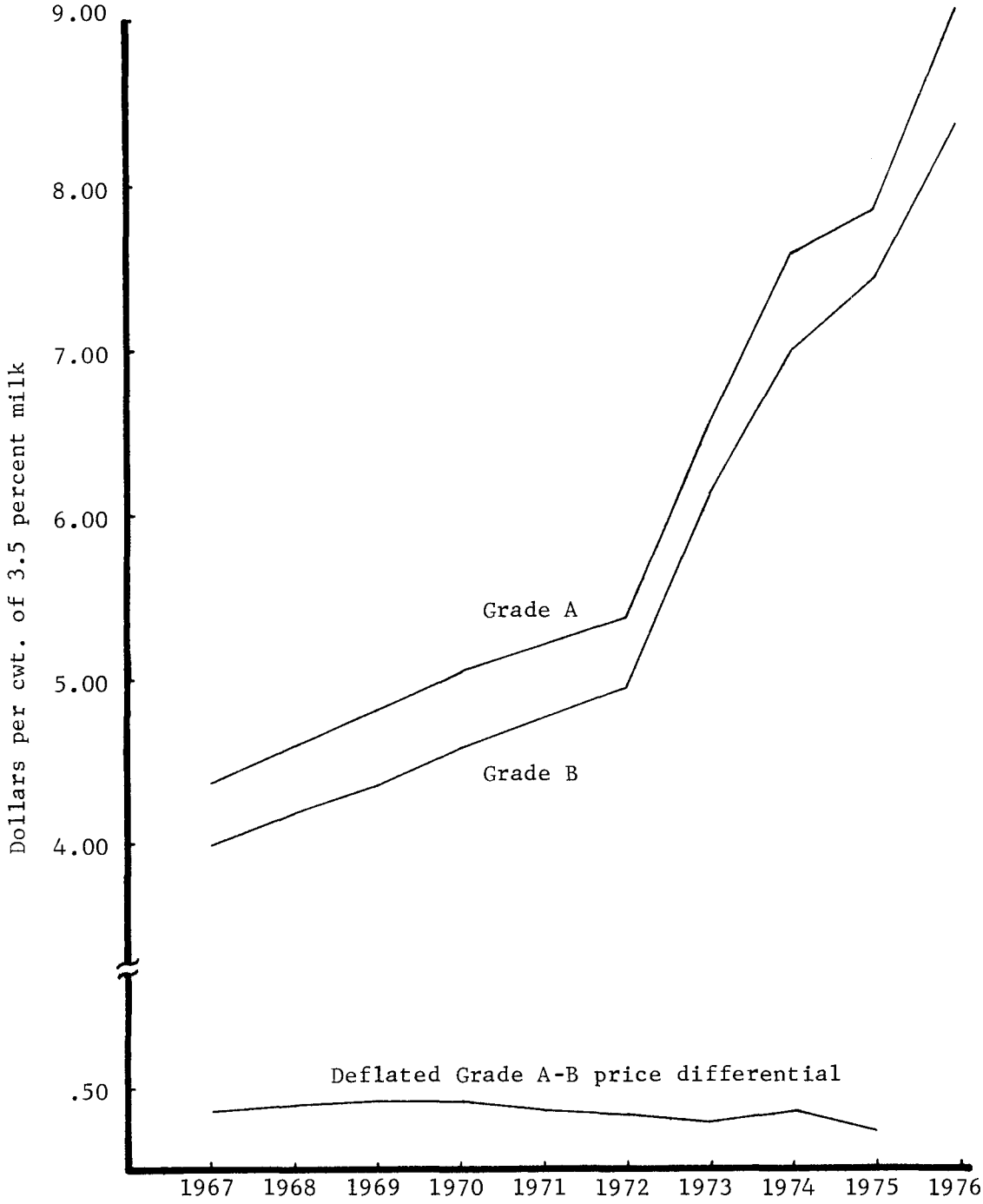

Figure 6. Minnesota average 3.5 percent price for Grade A and Grade B milk and deflated Grade A-B price differential, 1967-1976.

But, even though prices more than doubled in both markets during that time, the average differential changed very little. In fact, little overall change has occurred in the margin since 1960. Furthermore, if we deflate the differential to determine its real value, we see that it has actually declined during the period (see column 4 of Table 16 and Figure 6). The purchasing power of the differential is only about half of what it was in 1960.

The price difference between Grade A and Grade B in Minnesota and much of Wisconsin is much smaller than the national average because of the large milk supplies relative to local milk and milk product demands. In certain areas of Minnesota, Grade B farmers located near cheese plants often receive a price equal to, or occasionally higher than, the Grade A price in the area. Without more attractive and prolonged price differentials, conversion to Grade A is often curtailed.

(3) Twenty-two percent of the Grade B respondents indicated that they felt they were too old to make the investment to meet the additional requirements necessary for the shift to Grade A. For these producers, conversion would not be economically rational because they could not produce Grade A milk for a long enough duration to recover the additional fixed costs imposed.

(4) The inconvenience and bother of inspections restrict Grade B to Grade A conversion. Periodic inspections of the dairy facility are required on all Grade A dairy farms in the state. Fourteen percent of Grade B farmers in the survey answered that the inconvenience of these inspections was the main reason why they did not shift to Grade A.

In total, it appears that a large proportion of the Grade B producers find important limitations to shift to Grade A production. Furthermore, there is little indication that these conditions will change.

Factors Conducive to Grade A Milk Production

The preceding section considered factors that usually limit the Grade B to Grade A shift. There should be, however, in addition to higher price differentials, certain farm characteristics that are conducive to producing or shifting to Grade A milk. To determine this, we utilized a statistical model to sort out those characteristics which were significantly associated with Grade A milk production. 7/ The results of this analysis are interpreted as either probabilities that a farm with certain characteristics will produce Grade A milk

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7/ The technical approach is known as the probit model. For specific characteristics of the method, see the appendix.

or the percentages of all farmers that will be producing Grade A milk, given certain average conditions for all farms in the state. Both types of results are presented below.

Several of the farm characteristics described earlier were hypothesized as being related to Grade A or Grade B milk production. The statistical model indicated that only five were significantly related with type of operation: (1) number of cows, (2) hired labor, (3) artificial insemination, (4) bulk tanks, and (5) mechanical silage feeding. As with all statistical analyses, the direction of causation is not determined by the statistical results. Cause and effect are determined through use of theory and knowledge of operation of the system. In the following, we describe not only the statistical results but we comment on direction of causation.

Size of farm as measured by number of cows is directly related to the probability of producing Grade A milk. This may reflect a need to distribute higher fixed equipment and building costs over larger volumes. The absolute minimum size varies with other characteristics of the farm and the operator, but it appears to be a basic factor associated with Grade A milk production. According to the analytical model, the probability that a farmer with 30 cows produces Grade A milk is .28, whereas the probability that a farmer with a 60-cow herd produces Grade A is .67 (see Figure 7). It can be alternatively stated that about 28 percent of farms with 30 cows will be Grade A and 67 percent with herds of 60 cows will be Grade A.

The use of hired farm labor is significantly related to the Grade A or Grade B status of dairy farms. Figure 7 indicates that a dairy farm which annually utilizes 10 man-weeks of hired labor has a probability of .38 of being Grade A. A dairy farm which hired a full-time employee throughout the year has a .6 probability of being Grade A. This may imply that an operator and his family cannot supply both the managerial and total labor requirements on most large farms which are the Grade A farms. Alternatively, it may imply that the ability to find competent hired labor for the dairy farm determines whether a farm can continuously meet Grade A standards.

A strong relationship exists between the use of artificial insemination and the production of Grade A milk. Holding all other factors in the model at average values for the sampled farms, we find probabilities of Grade A production of .12 if artificial insemination is not used and .32 if artificial insemination is used. It is not readily discernible why this is the case. One hypothesis is that the most innovative farmers use artificial insemination and the innovative farmers are those which are capable of handling the added managerial requirements of a Grade A operation.

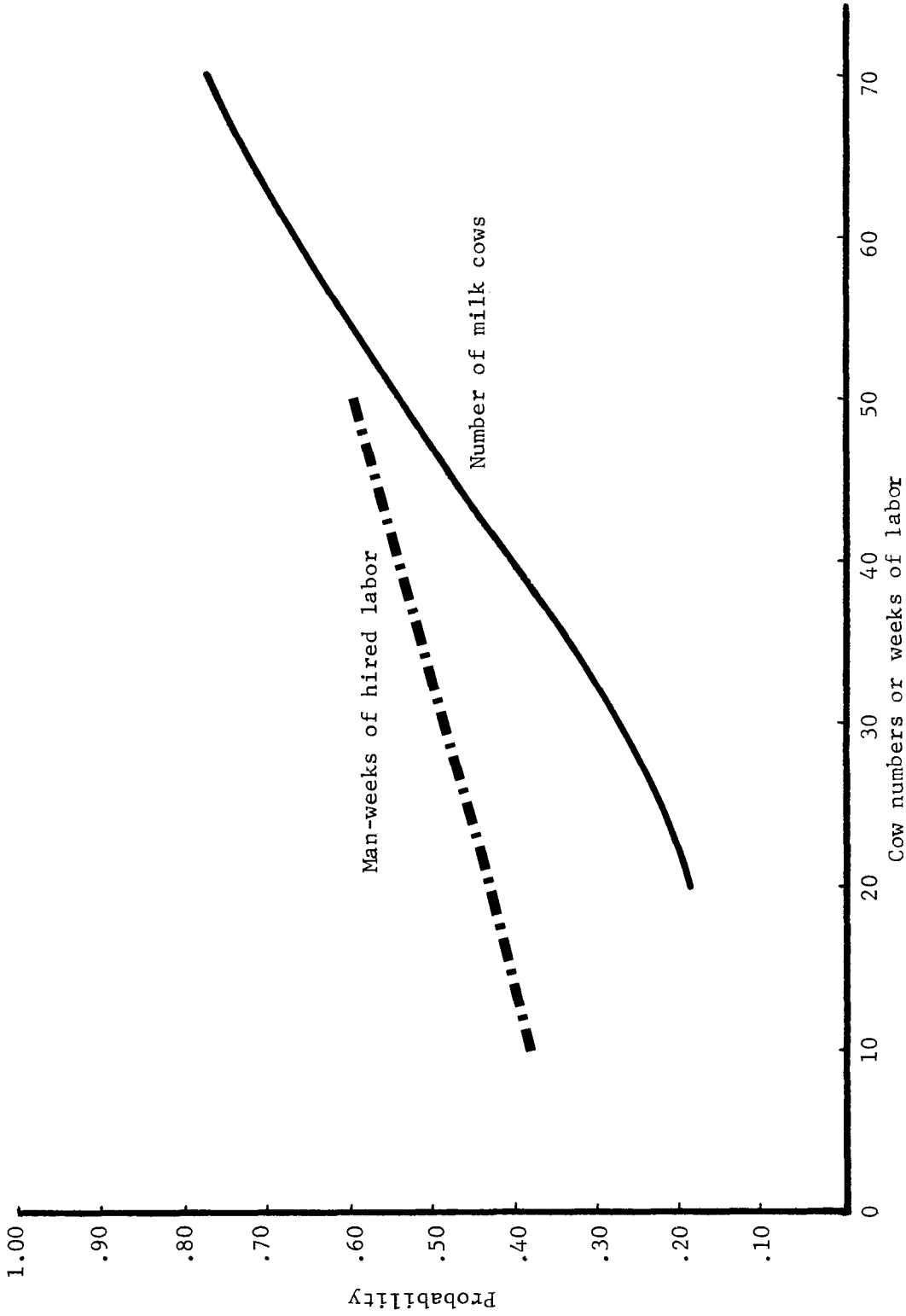

Figure 7. Probability of Grade A milk production according to size of dairy herd and amount of labor hired, Minnesota, 1976.

Dairy farmers who have bulk tanks are much closer to meeting Grade A requirements than those without. Thus, Grade B producers with bulk tanks would be expected to have a higher probability of conversion to Grade A than those producers without bulk tanks. The statistical analysis indicates that a producer with a bulk tank and with average values of the other factors has a probability of .45 of being Grade A.

High levels of mechanization increase the probabilities of Grade A production. Use of equipment which mechanically unloads silage from the silo and transfers it to feed bunks was significant in the analysis. The analytical model shows that if we hold other factors at their average levels, the probability of Grade A production is .42 if the producer has this equipment and only .23 if silage is fed by hand.

Projected Changes

The probit model can also be used to estimate the percentage of dairy farmers in Minnesota who will be producing Grade A milk in the future. In this case, future values for each variable were projected and substituted into the equation derived through use of the probit technique.

The assumed values for the appropriate variables in 1980 and 1985 are as follows:

(1) The average herd size in the state has increased at a consistent rate of about 1.2 cows per year since 1967. By assuming that this trend will continue, the average size of all dairy herds in Minnesota will increase from the present 28.3 cows to 33.1 in 1980 and 39.1 in 1985.

(2) The utilization of hired labor is assumed to increase at about the same rate as increases in herd size or about 3.6 percent annually. Under this assumption, paid labor will increase from the present 11.8 man-weeks to 13.5 in 1980 and 15.6 in 1985.

(3) The percentage of cows bred artificially has increased at an annual rate of about 1.9 percent since 1967. We are assuming that the trend will continue for the next few years and that the utilization of artificial insemination will increase from the present 74 percent to 81.6 percent in 1980 and 91.1 percent in 1985.

(4) Bulk tanks have been installed on Minnesota dairy farms at the rate of 3 percent annually since 1967. We expect the rate of adoption to decline to about 2.5 percent through 1980 and 2.0 percent through 1985. Under these assumptions, the percentage of farms with bulk tanks will increase from the present 70 percent to 80 percent in 1980 and 90 percent in 1985.

(5) The adoption of mechanized silage feeding systems in coming years is assumed to occur at a similar rate as bulk tank technology has been adopted in the previous decade (3.0 percent annually). This assumption implies that the percentage of dairy farms with this type of system will increase from 24 percent at present to 36 percent in 1980 and 51 percent in 1985.

Application of the above estimates to the probit equation yields the following result. The percentage of Grade A dairy farms in the state is projected to increase from the present 28 percent to 37 percent in 1980 and 46 percent in 1985. Currently, these 28 percent are the larger farms and account for 40 percent of the state's milk production. The 37 percent in 1980 will account for a much larger share of total milk production.

SUMMARY

Total Minnesota milk production declined by 10 percent between 1967 and 1976. The changes varied by location within the state. The decline was only 7.6 percent for the 33-county "dairy belt" that runs from the southeast to west central part of the state. Thus, the state's dairy industry continued to concentrate in that part of the state, from 71 percent in 1967 to 75 percent in 1976.

Average herd size continues to expand in the state, from 17.5 cows in 1967 to 28.3 in 1976. Minnesota still is fourth in average herd size of the four major milk producing states. Average herd size in Wisconsin is 33.4 cows. We have and will continue to experience declines in small-sized herds under 30 cows and increases in larger-sized herds. We project that between 1976 and 1986 the number of farms selling milk or cream in the state will decline from 29,500 to 19,200.

Characteristics of Minnesota dairy farms and their operators in 1976 were obtained from questionnaires received from 205 dairy farms. This permitted us to determine changes that had taken place since 1967 when a similar survey was made. Information was obtained on technology of production, labor and management characteristics, and planned adjustments by the operator.

Significant increases in mechanization of milk production have occurred since 1967. Only 5.3 percent of all farms in 1967 were using mechanical unloading of silos with mechanized distribution to the feed bunks. The percentage had increased to 24 percent of all farms in 1976. About 70 percent of all farms used bulk tanks in 1976 compared with 40.5 percent in 1967. Pipeline milkers have been a major change, from 4.2 percent of the farms in 1967 to 34.6 percent of the farms in 1976. Milking parlors are still not widely used on Minnesota dairy farms, only 10 percent in 1976 according to the survey.

The major change in feeding since 1967 has been a shift from hay to silage and a reduction in the average days on pasture from 70 to 39 days. It appears that silage feeding has substituted for both hay and pasture.

More than half of the sample farmers plan no herd size adjustments in the next five years. Fourteen percent plan to increase herd size and 32 percent plan to decrease herd size or dispose of all cows within five years. The rate of decline in herd numbers implied by these responses is consistent with the projections cited above.

Analysis of the Grade B to Grade A shift indicates that we will have a considerable number of Grade B producers for the foreseeable future. One reason for no major acceleration of the shift is the lack of a large Grade A to Grade B price differential in Minnesota. In fact, in real terms, this differential has declined since 1960. Other factors are conducive to shifting milk producers to Grade A status, but our analysis indicates a relatively moderate change by 1985. Currently, 28 percent of Minnesota farms are Grade A quality and they account for 40 percent of milk produced. Unless major Grade A to Grade B differentials develop, the proportion of farms that are Grade A is not likely to exceed 46 percent by 1985.

APPENDIX

The application of the probit statistical model to characteristics of a sample of Minnesota dairy farmers indicated that five factors were significantly associated with the probability of Grade A or Grade B milk production. These were number of cows per farm, amount of hired labor, the use of artificial insemination, bulk tank milk handling, and mechanization in feeding. The estimated equation for the relationship is:

$$I_i = -3.142 + .018\ X_1 + .010\ X_2 + .746\ X_3 + 1.585\ X_4 + .539\ X_5$$

where:

I_i is the probit index,

X_1 is number of cows per farm,

X_2 is man-weeks of hired labor,

X_3 is use of artificial insemination (X_3 is 1 if artificial insemination is used and 0 if not used),

X_4 is use of a bulk milk tank (X_3 is 1 if bulk milk tank is used and 0 if not used), and

X_5 is use of mechanized silage unloading and feeding (X_5 is 1 if mechanized and 0 if not used).

Standard errors of the estimated coefficients are listed in Appendix Table 1.

The equation is used as follows in calculating the probability of Grade A milk production. Suppose a dairy farmer milks 30 cows, hires 20 man-weeks of labor annually, uses artificial insemination, has a bulk tank, and mechanically unloads the silo and distributes the silage. a/ Use of these values in the above equation yields $-3.142 + .018(30) + .010(20) + .746(1) + 1.585(1) + .539(1) = .468$. This value is transformed into a probability by the use of Appendix Table 2. Reference to that table indicates that for the value of .468, the probability is .68 that the farmer will be producing Grade A milk. b/

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a/ For estimating the proportions of producers in the population that are likely to be Grade A, the variables X_3, X_4, and X_5 can take on the values of the proportion of farms with the respective characteristics.

b/ For negative values of the index, subtract the table value from 1.0.

Appendix Table 1. Probit estimates from equations analyzing conversion from Grade B to Grade A milk production by Minnesota farmers.

Variable	Parameter	Standard error
Constant term	-3.142	0.523
Number of cows	0.018	0.007*
Hired labor	0.010	0.007***
Artificial insemination	0.746	0.269*
Bulk tank	1.585	0.457*
Mechanical silage feeding	0.539	0.285**

* Significant at 1 percent level.
** Significant at 5 percent level.
*** Significant at 10 percent level.

Appendix Table 2. Cumulative normal probabilities.

z	F(z)	z	F(z)	z	F(z)	z	F(z)
.00	.500	.36	.641	.72	.764	1.08	.860
.01	.504	.37	.644	.73	.767	1.09	.862
.02	.508	.38	.648	.74	.770	1.10	.864
.03	.512	.39	.652	.75	.773	1.11	.867
.04	.516	.40	.655	.76	.776	1.12	.869
.05	.520	.41	.659	.77	.779	1.13	.871
.06	.524	.42	.663	.78	.782	1.14	.873
.07	.528	.43	.666	.79	.785	1.15	.875
.08	.532	.44	.670	.80	.788	1.16	.877
.09	.536	.45	.674	.81	.791	1.17	.879
.10	.540	.46	.677	.82	.794	1.18	.881
.11	.544	.47	.681	.83	.797	1.19	.883
.12	.548	.48	.684	.84	.800	1.20	.885
.13	.552	.49	.688	.85	.802	1.21	.887
.14	.556	.50	.691	.86	.805	1.22	.889
.15	.560	.51	.695	.87	.808	1.23	.891
.16	.564	.52	.698	.88	.811	1.24	.893
.17	.567	.53	.702	.89	.813	1.25	.894
.18	.571	.54	.705	.90	.816	1.26	.896
.19	.575	.55	.709	.91	.819	1.27	.898
.20	.579	.56	.712	.92	.821	1.28	.900
.21	.583	.57	.716	.93	.824	1.29	.901
.22	.587	.58	.719	.94	.826	1.30	.903
.23	.591	.59	.722	.95	.829	1.31	.905
.24	.595	.60	.726	.96	.831	1.32	.907
.25	.599	.61	.729	.97	.834	1.33	.908
.26	.603	.62	.732	.98	.836	1.34	.910
.27	.606	.63	.736	.99	.839	1.35	.911
.28	.610	.64	.739	1.00	.841	1.36	.913
.29	.614	.65	.742	1.01	.844	1.37	.915
.30	.618	.66	.745	1.02	.846	1.38	.916
.31	.622	.67	.749	1.03	.848	1.39	.918
.32	.626	.68	.752	1.04	.851	1.40	.919
.33	.629	.69	.755	1.05	.853	1.41	.921
.34	.633	.70	.758	1.06	.855	1.42	.922
.35	.637	.71	.761	1.07	.858	1.43	.924

SOURCE: William L. Hays and Robert L. Winkler, Statistics: Probability, Inference, and Decision, Holt, Rinehart and Winston, Inc., New York, p. 275.

Appendix Table 3. Number of farms selling milk or cream at mid-year, Minnesota, 1967-1976.

	Grade A	(percent change)	Grade B	(percent change)	Cream	(percent change	Total	(percent change)
1967	4,841		46,172		5,721		56,734	
1968	5,157	+6.5	42,171	-8.7	4,437	-22.4	51,765	-8.8
1969	5,346	+3.6	37,734	-10.5	3,209	-27.7	46,289	-10.6
1970	6,439	+20.4	34,206	-9.3	2,770	-13.7	43,415	-6.2
1971	6,687	+3.9	32,070	-6.2	1,434	-48.2	40,191	-7.4
1972	7,760	+16.0	30,944	-3.5	874	-39.1	39,578	-1.5
1973	7,951	+2.5	28,652	-7.4	783	-10.4	37,386	-5.5
1974	8,236	+3.6	25,530	-10.9	432	-44.8	34,198	-8.5
1975	8,514	+3.4	23,963	-6.1	319	-26.2	32,796	-4.1
1976	8,294	-2.6	22,078	-7.9	248	-22.3	30,620	-6.6

SOURCE: Minnesota Department of Agriculture, Division of Field Accounting.

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