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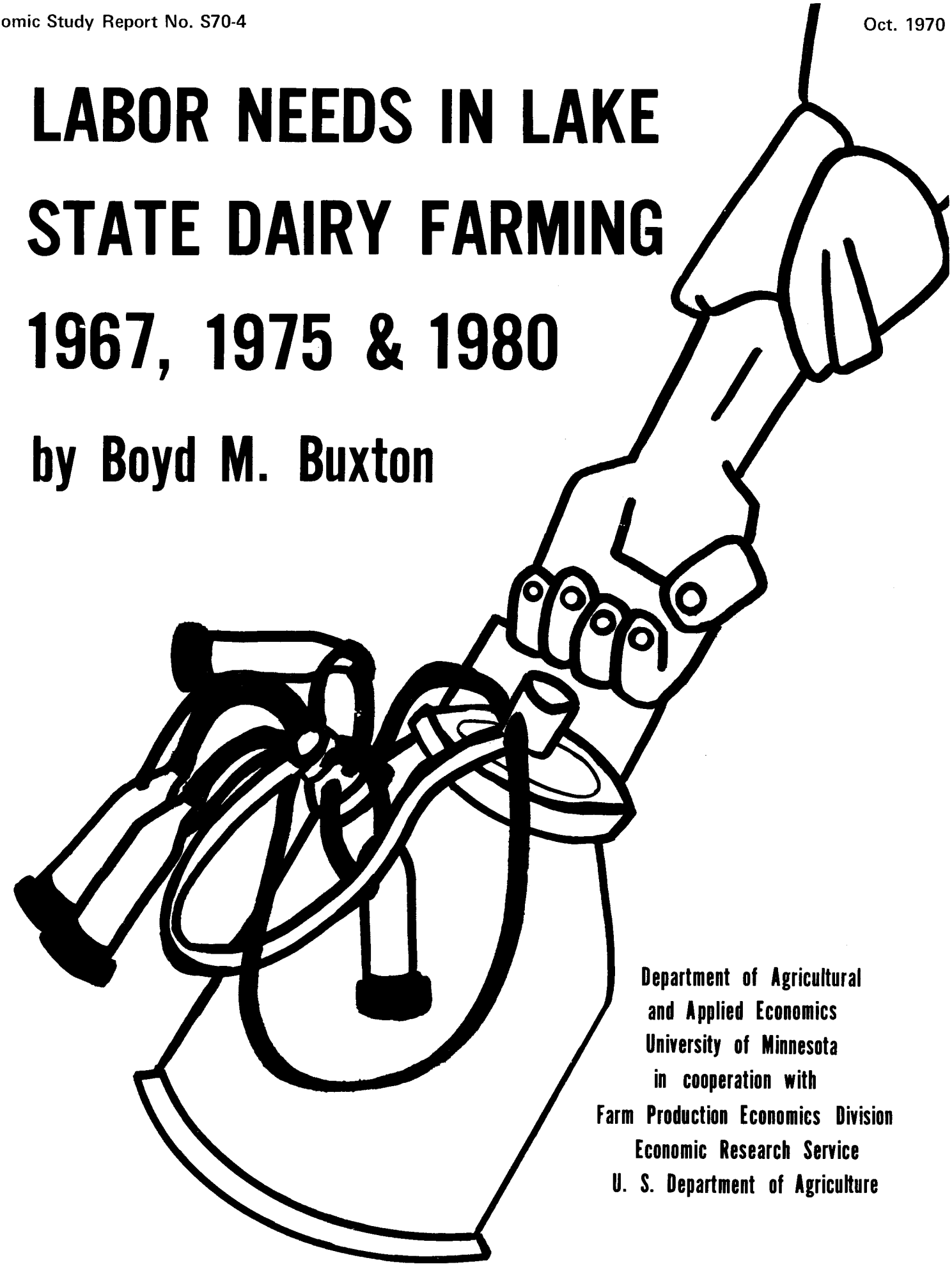
Economic Study Report No. S70-4

Oct. 1970

LABOR NEEDS IN LAKE STATE DAIRY FARMING 1967, 1975 & 1980

by Boyd M. Buxton



Department of Agricultural
and Applied Economics
University of Minnesota
in cooperation with
Farm Production Economics Division
Economic Research Service
U. S. Department of Agriculture

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Boyd M. Buxton

Agricultural Economist
Farm Production Economics Division
Economics Research Service
Stationed at the
Department of Agricultural and Applied Economics
University of Minnesota
St. Paul, Minnesota 55101

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INTRODUCTION

Sharp decreases in the number and increases in the sizes of dairy herds and substitution of technology for labor characterizes Lake States dairy production. These changes have influenced greatly the labor required for dairy production. On the basis of past trends, projections are made of the expected changes in dairy production to 1975 and 1980. The impacts of these changes on the labor needed for dairy production are evaluated. Future labor inputs in dairy production will depend on:

1) changes in the technologies used in dairy production and

2) changes in the number and sizes of dairy herds.

Information on dairy technologies used in the Lake States and the labor requirements of alternative dairy technologies are summarized in the first part of the report. The second part summarizes the projected changes in the number and sizes of dairy herds. Finally, the impact of these changes on the Lake States dairy labor needs is evaluated.

Lake States dairy technology, 1967

The dairy technology used in the Lake States was estimated from a special mail survey, summarized in appendix C. Survey results show that many Lake States dairy producers still are using labor intensive methods of handling, caring for, and milking dairy cows. In terms of housing, 97 percent used conventional stanchion barns. Only 3 percent had loose housing milking parlor facilities. About 82 percent of the farmers hand carried milk to the storage area. Sixty-three percent of the farmers unloaded upright silos by hand, and 41 percent loaded manure by hand into

a litter carrier or manure spreader. The relatively large proportion of farmers still using unmechanized systems for handling their dairy herds results in relatively high labor inputs for milk production. Labor per cow may exceed 140 hours per year on small herds using unmechanized stanchion barn facilities; it may drop to less than 45 hours on larger herds housed in loose housing and milked in milking parlors. Each dairy producer surveyed was identified with one of 15 dairy systems according to the dairy technology they used (table 1).

For each of the three Lake States, the proportion of all dairy producers using each of the 15 systems was estimated by herd size (table 2).

Results show that smaller herd owners use relatively less labor-saving technology than do larger herd owners. The proportion of producers using system number 15 (loose housing with milking parlor) was relatively high for larger herd size groups in all three states. However, in Wisconsin system number 15 was used by only 8.2 percent of the herds with more than 50 cows compared with 42.2 and 46.7 percent in Minnesota and Michigan, respectively. Over 80 percent of the farms with less than 10 milk cows used system number one (stanchion barn with manure loading, silo unloading, and transferring of milk all done by hand). This system accounted for a much smaller proportion of the larger herds in all three states.

Number and sizes of dairy herds

The changes to fewer and larger dairy herds influence labor use in two important ways. First, relatively more laborsaving technology will

Table 1. Identification of 15 systems of feeding, caring for, and milking dairy cows and the estimated annual labor inputs, Lake States Region

System code	Technology used					Annual labor‡	
	Housing & milking	Manure disposal	Pasture	Silo unloader	Type of milk transfer to storage	Fixed (hours)	Per adult cow (hours)
1	Stanchion	Hand loading	Yes	No	Carry	776	63.0
2	Stanchion	Gutter cleaner	Yes	No	Carry	769	60.8
3	Stanchion	Gutter cleaner	Yes	Yes	Carry	743	60.8
4	Stanchion	Gutter cleaner	No	Yes	Carry	821	63.6
5	Stanchion	Hand loading	No	No	Carry	883	67.1
6	Stanchion	Gutter cleaner	Yes	Yes	Dump station	925	45.3
7	Stanchion	Gutter cleaner	No	Yes	Dump station	998	50.2
8	Stanchion	Hand loading	Yes	Yes	Carry	756	63.0
9	Stanchion	Gutter cleaner	Yes	No	Dump station	946	47.3
10	Stanchion*	Hand loading	Yes	No	+	441	74.6
11	Stanchion	+	+	+	Pipe line	1035	43.1
12	Stanchion*	+	+	+	+	492	75.2
13	Stanchion	+	No	+	Carry	854	64.4
14	Stanchion	+	+	+	Dump station	964	49.9
15	Loose housing & parlor	Tractor loader	+	+	Pipe line	690	42.0

* Switch systems. Cows milked in bathces in stanchion barn.

+ Average labor for all technologies was used to compute labor because too few farms permit more detailed breakdown.

‡ Annual labor per herd required for feeding, caring for, and milking the dairy herd in designated systems. See Appendix E for further description of fixed and variable labor.

Table 2. Estimated proportion of farms in each herd size group by 15 dairy technology systems.*

System Code	Michigan 1-9 Cows	Michigan 10-19 Cows	Michigan 20-29 Cows	Michigan 30-49 Cows	Michigan 50+ Cows	Minnesota 1-9 Cows	Minnesota 10-19 Cows	Minnesota 20-29 Cows	Minnesota 30-49 Cows	Minnesota 50+ Cows	Wisconsin 1-9 Cows	Wisconsin 10-19 Cows	Wisconsin 20-29 Cows	Wisconsin 30-49 Cows	Wisconsin 50+ Cows
	Percent of farms														
1	80.8	73.8	36.7	4.8	2.8	88.4	73.6	41.1	14.2	0	81.7	75.9	42.2	13.5	0.4
2	0	2.6	16.6	9.8	3.4	2.4	3.2	13.6	17.5	2.2	4.4	10.9	29.7	26.7	22.7
3	0	0.7	3.9	6.9	0	0	1.2	6.4	17.3	2.2	0	4.1	12.1	17.1	18.4
4	0	0	1.5	5.7	0.6	0	1.9	6.4	7.8	4.5	0	0	1.3	6.9	5.6
5	17.7	11.3	6.3	4.1	2.8	3.4	8.5	3.4	7.4	2.2	13.9	6.9	5.7	2.4	0
6	0	0.9	0	4.9	9.6	0	0	6.9	6.6	2.2	0	0	1.0	8.0	19.2
7	0	0.9	0.7	4.0	2.8	0	1.9	6.4	7.8	4.5	0	0	0.5	4.0	6.5
8	0	3.4	2.1	2.8	0	1.9	4.4	3.5	1.7	0	0	0	1.1	0.4	2.8
9	0	0	4.0	9.8	13.0	0	0.6	0.7	3.7	0	0	0	0.9	5.4	6.3
10	0	1.6	3.6	7.8	0	0	2.0	3.5	0.9	0	0	0	1.0	0	0
11	0	1.6	1.5	5.7	0.6	0	0	3.2	1.9	10.7	0	0	0.6	5.6	6.4
12	0	0.9	3.6	6.8	11.8	0	0.7	0.2	5.4	10.7	0	0	0.5	1.4	3.1
13	0	1.6	10.3	7.2	3.4	0	2.0	2.1	1.7	4.5	0	0.7	2.1	5.1	0.4
14	1.5	0	1.2	3.2	2.5	3.9	0	2.1	3.6	14.1	0	1.5	1.3	1.6	0
15	0	0.7	8.0	16.5	46.7	0	0	0.5	2.5	42.2	0	0	0	1.9	8.2
Total	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100

*Source: Buxton, Boyd M. and Michael J. Hay, "Milk Production Practices on Dairy Farm in the Lake States -- 1967" unpublished data. Department of Ag. Econ., University of Minnesota, June 1969.

be used in dairy production in the future because the smaller herd owners going out of dairying generally use less laborsaving technology than do the larger herd owners who have increased in number. Therefore, on the average the owners of larger, remaining herds will be using more labor-saving technology. Second, a substantial amount of dairy chore labor on each farm does not depend on the number of cows milked, and the trend to fewer farms will result in less of this fixed labor being tied up in total dairy production (appendix E).

Projections to 1975 and to 1980

The number and size distribution of dairy herds were projected to 1975 and to 1980 for the three Lake States. Projections for Minnesota and Wisconsin were made with the Markov chain technique using the state farm census data on number and sizes of dairy herds. 1/ For Michigan, where no state farm census is taken, projections reflect U. S. agricultural census data and projections made at Michigan State University. 2/

Projections are illustrated in figures 1 to 3 and table 3. Results show major decreases in the number of farms with one to nine and 10 to 19 cows and a substantial decline in 20 to 29 cow herds by 1980. Herds having 30 to 49 cows will continue to be the major size group, while the number of herds with 50 or more cows will more than double by 1980. In

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1/ For further discussion of the Markov chain technique, see appendix D.

2/ Dairy Statistics 1960-67, U. S. Department of Agriculture, Economic Research Service, Statistical Bulletin No. 430, July 1968, p. 47 and Project 80 Farm Science, D. L. Murray, C. R. Hoglund, and A. L. Rippen, "The Dairy Farm Enterprise," Agr. Exp. Sta. Res. Rpt. No. 45, Michigan State University, East Lansing, Michigan, pp. 2-5.

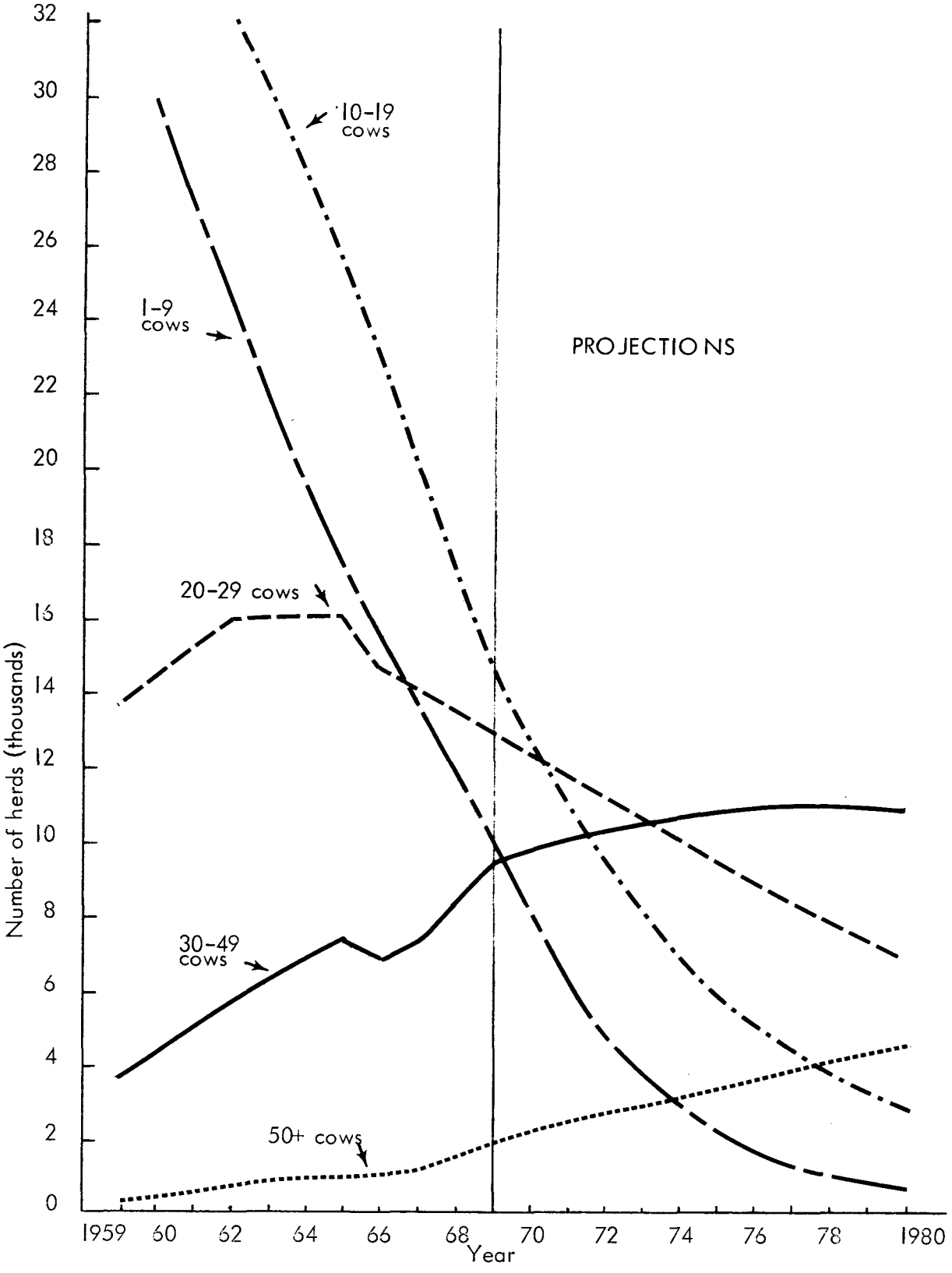

Figure 1. Number and herd size distribution of farms reporting milk cows in Minnesota, 1959-1969 and projections to 1980.

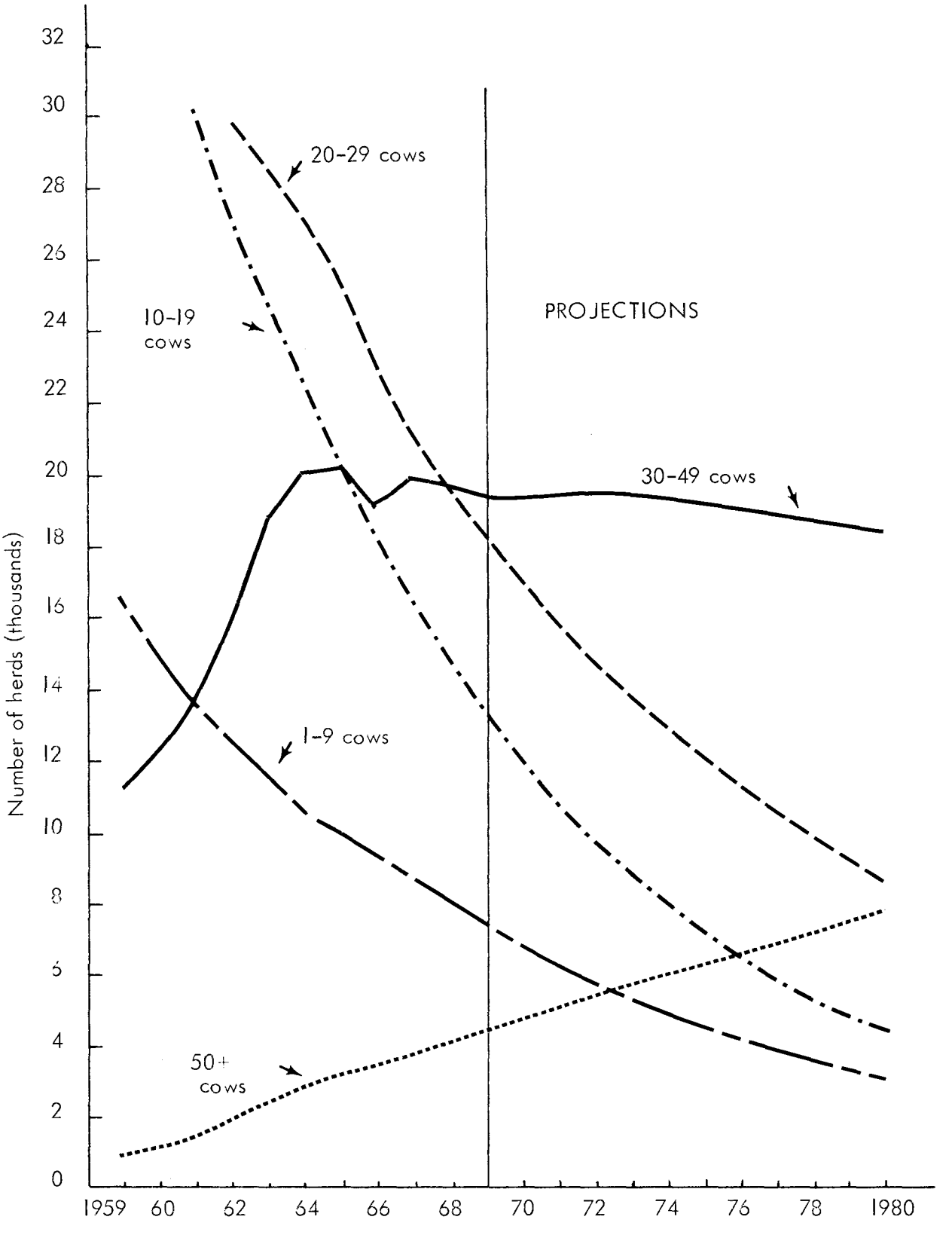

Figure 2. Number and herd size distribution of farms reporting milk cows in Wisconsin, 1959-1969 and projections to 1980.

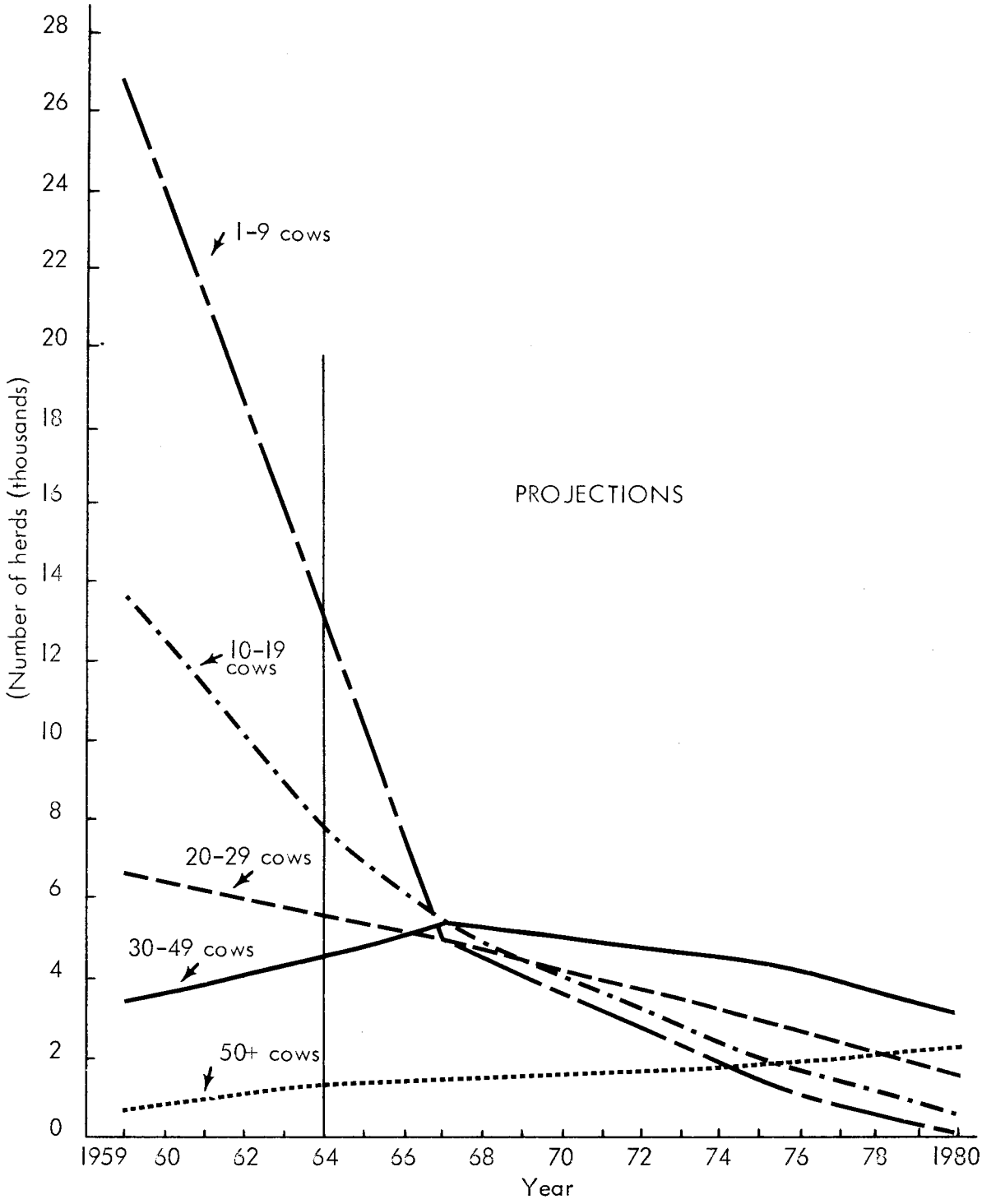

Figure 3. Number and herd size distribution of farms reporting milk cows in Michigan, 1959-1969 and projections to 1980.

Table 3. Present and projected number and size distribution of dairy herds, number of cows and total milk production, Lake States

Herd size groups and item	Michigan			Minnesota			Wisconsin			Lake States		
		Projected			Projected			Projected			Projected	
	1967*	1975	1980	1967	1975	1980	1967	1975	1980	1967	1975	1980
						Number of Herds						
1-9 cows	4,963	1,500	200	13,851	2,247	640	8,957	4,509	3,021	24,771	8,256	3,861
10-19 cows	5,500	2,000	700	19,850	5,925	2,786	16,477	7,159	4,294	41,503	15,084	7,780
20-29 cows	5,000	3,000	1,700	14,052	9,470	6,862	21,302	12,034	8,506	40,354	24,504	17,068
30-49 cows	5,500	4,500	3,200	7,157	10,835	10,933	19,854	19,064	18,252	32,511	34,399	32,385
50 + cows	1,450	1,800	2,400	1,129	3,381	4,529	3,804	6,274	7,764	6,383	11,455	14,693
Total	22,413	12,800	8,200	56,039	31,858	25,750	70,394	49,040	41,837	148,846	93,698	75,787
						Number of Cows in Thousands						
Total	495	381	318	1,094	920	882	1,930	1,657	1,583	3,519	2,958	2,783
						Production Per Cow in Pounds Per Year						
Total	9,430	11,750	13,000	9,360	11,157	12,285	9,440	10,875	11,758	9,417	11,086	12,084
						Total Milk Production in Million Pounds						
Total	4,706	4,477	4,134	10,240	10,264	10,835	18,219	18,020	18,613	33,165	32,761	33,582

* Herd size categories for Michigan in 1967 were estimated so as to be consistent with total herds, the number of cows, production per cow, and total milk production in 1967.

total, the number of dairy herds in the Lake States is expected to decrease from about 148,800 in 1967 to about 76,000 in 1980, or almost 73,000 fewer herds.

Projected Milk Production

Average milk production per cow is likely be 13,000, 12,300, and 11,800 pounds in Michigan, Minnesota, and Wisconsin, respectively by 1980 (fig. 4). Production per cow projections were determined by extending past linear trends.

These projections of number and size of herds suggest that total milk production in the Lake States will remain slightly more than 33 billion pounds through 1980. The author of a detailed study on dairy product consumption patterns by U. S. consumers estimates that domestic consumption of milk would likely decrease 5 to 10 percent by 1980. 3/ The projected decrease in U. S. demand and utilization combined with the gradual increase in the Lake States' share of total U. S. milk production are consistent with the projections for milk production in the Lake States as reflected by the projected number and sizes of dairy herds.

Shifts in location of milk production

All except two counties in the three Lake States had fewer milk cows in 1968 than in 1960. However, the decline in importance of dairying

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3/ Burk, Marguerite C., "Prospects for U. S. Consumption of Dairy Products," Economic Study Report S69-4, Dept. of Agricultural and Applied Economics, University of Minnesota.

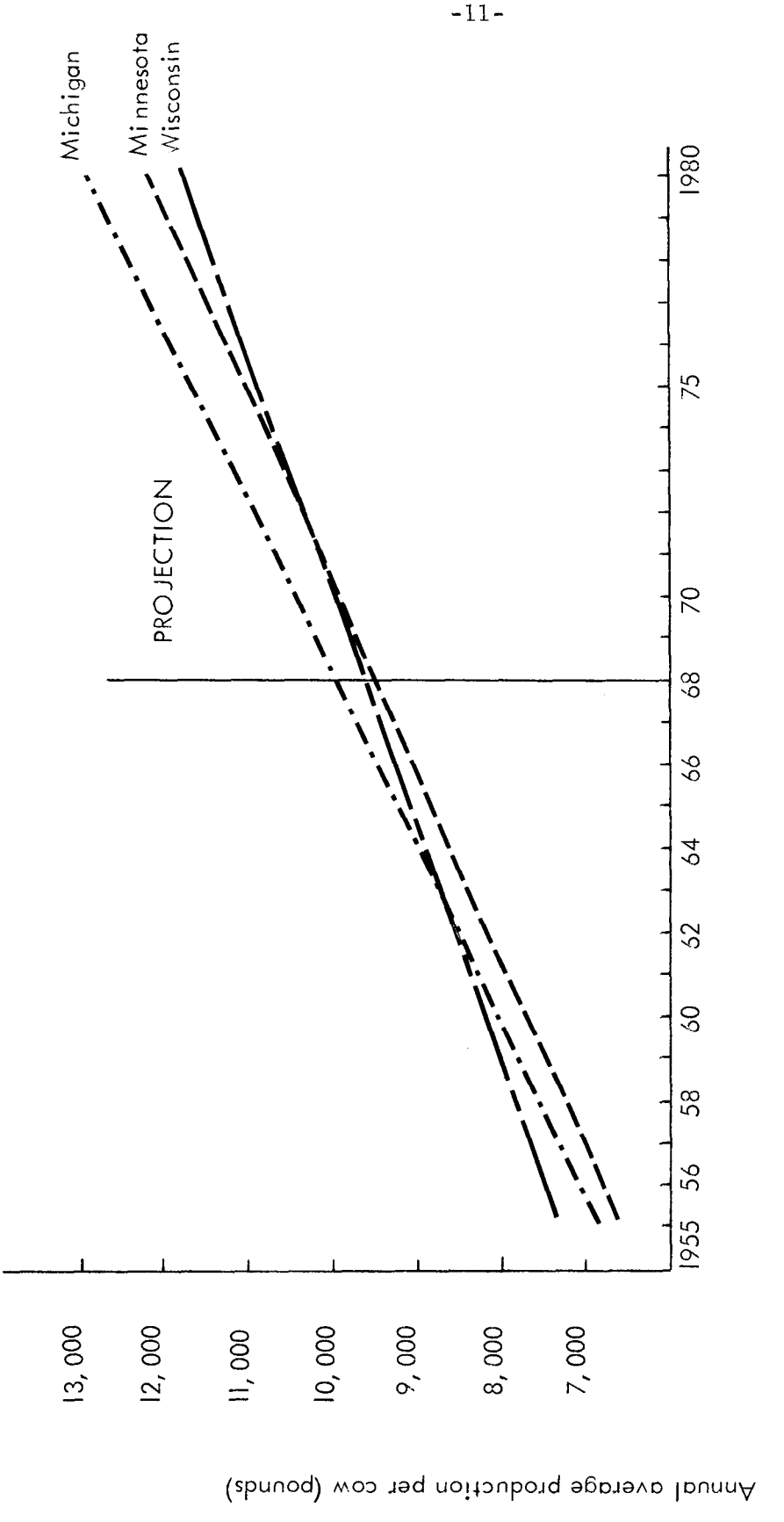


Figure 4. Average milk production per cow in three Lake States, least square regression for 1955 to 1968 and linear trend projections to 1980.

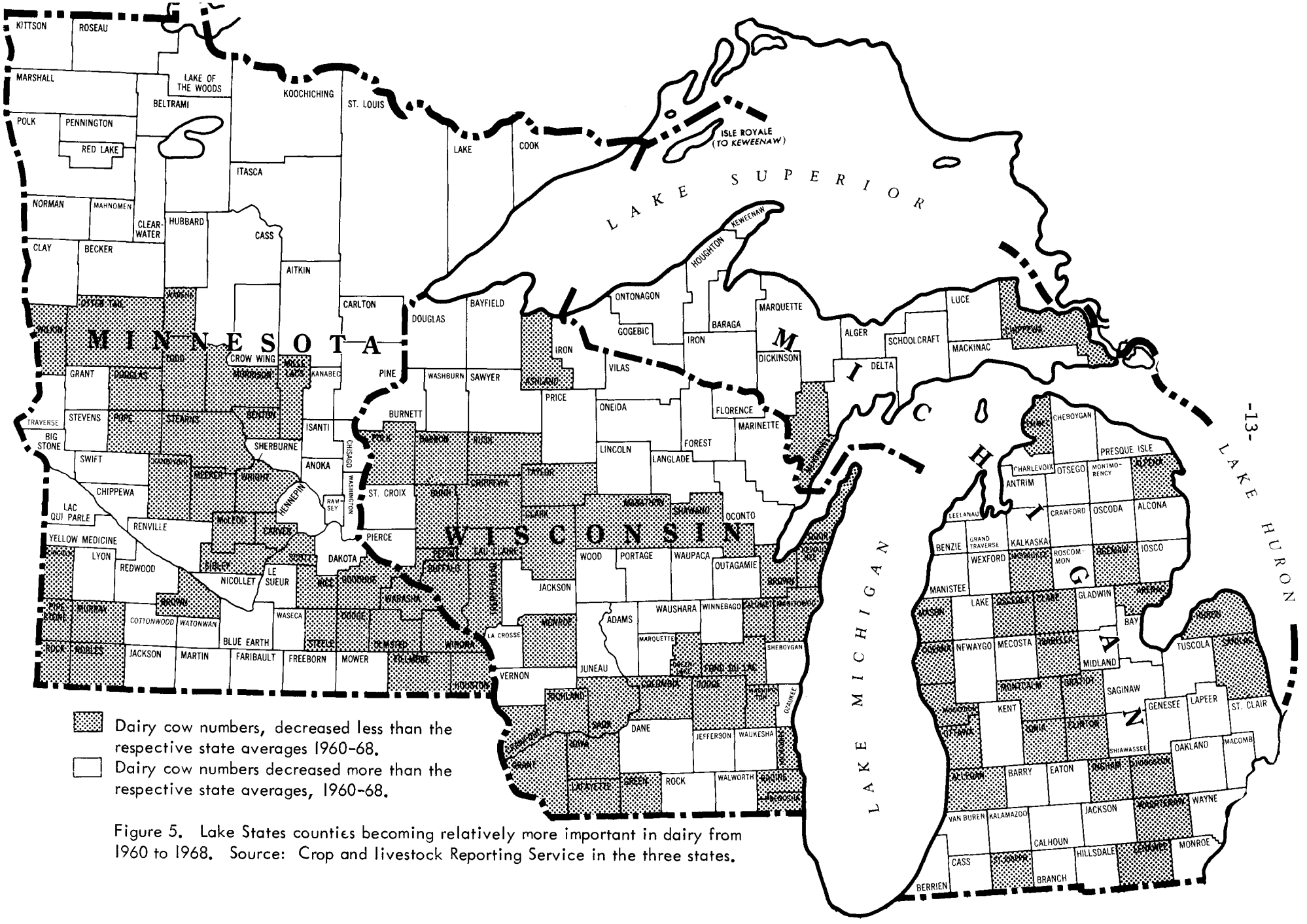
varied within each state (fig. 5). In Minnesota, dairying is becoming relatively more concentrated in the dairy belt which extends from the extreme southeast part of the state northwest to the Fargo-Moorhead area and in the southwest corner of the state. The northern counties, the highly populated Twin Cities Metropolitan area, and the good cropland areas in southcentral and westcentral Minnesota are becoming relatively less important dairy areas. A clear pattern is not as evident in Wisconsin and Michigan except that in the northern counties (especially Michigan's upper peninsula) dairy cow numbers are declining faster than state averages.

Changes in labor use by 1975 and 1980

The projected changes in Lake States dairy production will have an important effect on the labor use and employment potential of dairy farming in the region. The effect is divided into two parts: (1) the effect on the labor used directly for dairy production (dairy chore labor) and (2) the effect on total labor employed on farms producing milk (including types and seasonal distribution of labor).

(1) Dairy chore labor

The combined impact of fewer and larger dairy herds and a larger proportion of herds using laborsaving technologies will reduce by an estimated 33 percent the total labor input directly needed in dairy production by 1980. This is a decrease of 37 percent for Minnesota, 28 percent for Wisconsin, and 46 percent for Michigan (fig. 6 and table 4).



Dairy cow numbers, decreased less than the respective state averages 1960-68.

Dairy cow numbers decreased more than the respective state averages, 1960-68.

Figure 5. Lake States counties becoming relatively more important in dairy from 1960 to 1968. Source: Crop and livestock Reporting Service in the three states.

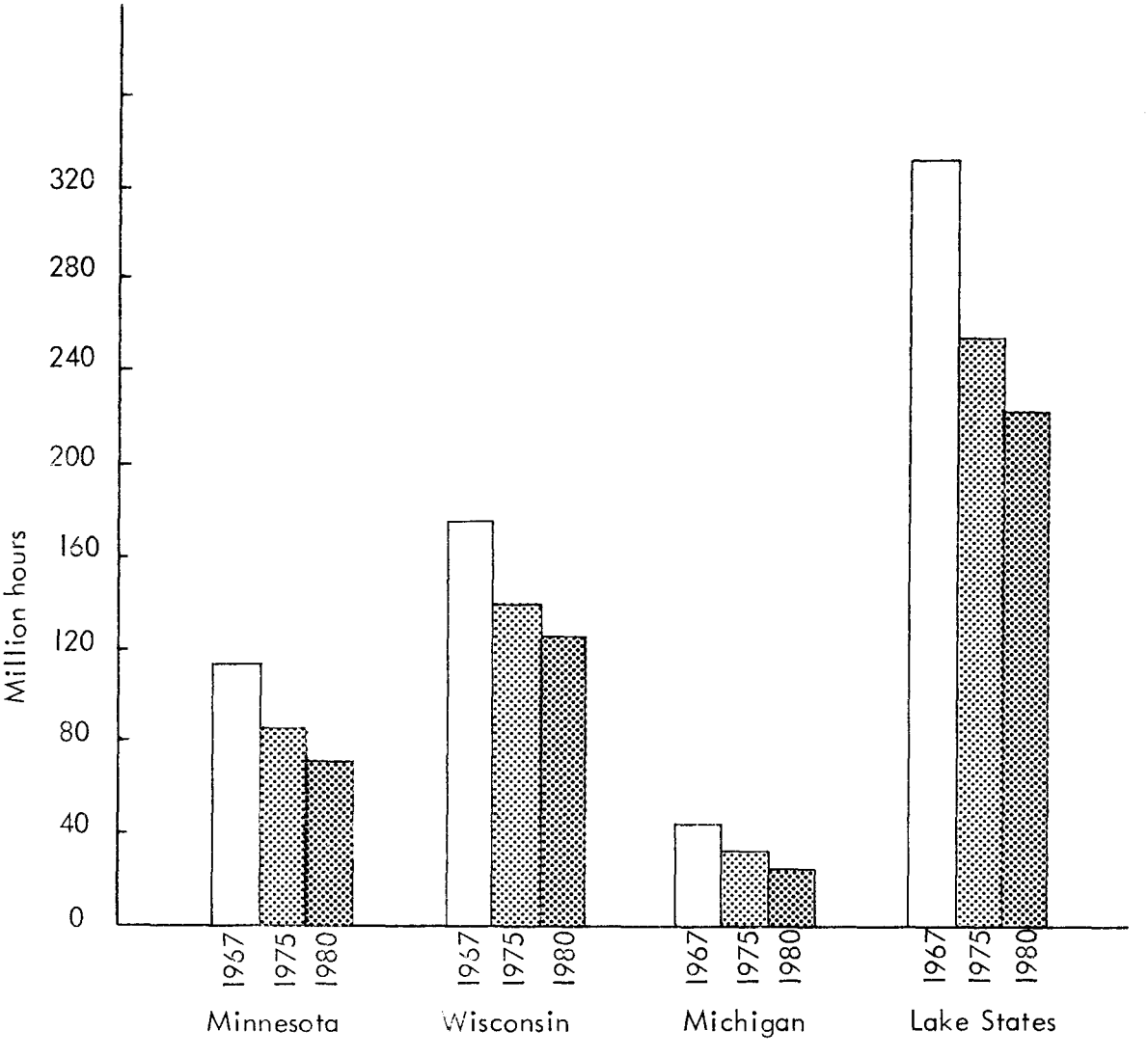


Figure 6. Total hours of dairy chore labor in 1967 and projections to 1975 and 1980, Lake States Region.

Table 4. Present and projected chore labor needed for feeding, caring for, and milking Lake States dairy cows

	1967	1975	1980
Total annual dairy labor (1,000 hours)			
Minnesota	113,696	84,488	71,871
Wisconsin	175,900	138,268	126,863
Michigan	43,573	31,292	23,531
Lake States	333,169	254,048	222,265
Annual labor per cow (hours)			
Minnesota	103.9	91.8	81.5
Wisconsin	91.5	83.4	80.1
Michigan	88.0	82.1	74.0
Lake States	94.7	85.9	79.9
Labor per cwt. of milk (hours)			
Minnesota	1.11	0.82	0.66
Wisconsin	0.97	0.77	0.68
Michigan	0.93	0.70	0.57
Lake States	1.00	0.78	0.66
Annual labor per herd (hours)			
Minnesota	2,029	2,652	2,791
Wisconsin	2,499	2,819	3,032
Michigan	2,245	2,445	2,870
Lake States	2,284	2,711	2,932

However, the absolute decrease will be greatest in Wisconsin where the annual labor needed will decline more than 49 million hours. For the Lake States region, almost 111 million fewer hours of labor will be needed annually by 1980. This represents a decrease of more than 53 thousand man equivalents of labor per year. 4/

Given the dairy technology used and the number and size distribution of dairy herds in 1967, an estimated 95 hours of labor per cow per year was used for dairy chore activities. This ranged from a high of 104 hours in Minnesota to 88 hours in Michigan. The differences among the Lake States were due to differences in herd size and the proportions of herd owners using the laborsaving technologies.

The projected changes in the Lake States region show that hours of labor per cow per year will decline to about 86 in 1975 and 80 in 1980. Less labor per cow will be needed in each of the Lake States; Michigan will continue to be the most labor efficient reflecting the generally larger herds and larger proportion of herd owners using laborsaving technologies.

The above labor estimates combined with the expected increase in average production per cow mean that the hours of labor per 100 pounds of milk produced will decline from about 1.00 in 1967 to 0.66 in 1980 (table 4).

The average chore labor used per dairy herd was estimated at about 2,300 hours in 1967 and is projected to increase to about 2,700 and 3,000

4/ A man equivalent is based on fifty-two, 40-hour weeks, a total of 2080 hours per year.

hours by 1975 and 1980, respectively. The implication of increased hours of dairy chore labor per farm is that farms will have to become more specialized (drop nondairy enterprises to free up additional labor) and/or on the average hire more labor. The result, which probably will be a combination of both, is considered further in the next section.

(2) Total farm labor

Total labor used on farms producing milk includes the hours worked by the farm operators, their wives, unpaid family members, and regular hired and seasonal hired workers. Total labor, therefore, includes the hours used directly on dairy chore activities discussed in the previous section plus the hours used on all other crop and nondairy livestock enterprises. In 1964, the average hours of labor worked per year on Lake States farms using stanchion barn facilities and on farms with milking parlor facilities were 6,917 and 8,462, respectively (table 5). Whether the farms were stanchion or parlor, the operator, his wife, and unpaid family worked about the same total number of hours. However, farm operators with milking parlors hired almost three times as much labor (regular and seasonal) as did operators with stanchion barns. On both stanchion and parlor farms, dairy was the major enterprise. On the average, the more mechanized parlor farms were more specizlized in dairy production than stanchion farms (73 compared with 62 percent of total farm sales from the dairy enterprise) and had larger dairy herds (484,700 compared with 252,300 pounds of milk produced per farm). These results show that owners using the more mechanized milking parlor technology produce more milk, are more specialized in dairy, and hire more labor.

Table 5. Average employment of various types of labor on farms using stanchion barns and milking parlor technologies, Lake States, 1964

	Total farm labor	
Type of labor	Stachion barn	Milking parlor
Operator	3,581	3,868
Wife	875	570
Unpaid family	1,662	1,686
Regular hired	368	787
Seasonal hired	431	1,551
Total Hours	6,917	8,462
Percent income from dairy	62	73
Average pounds of milk produced	252,300	484,700

Source: "1964 Pesticides Uses Survey," U. S. Department of Agriculture Economic Research Service, FPED, 1965.

According to the estimated number of dairy herds milked in stanchion barn facilities and in parlor facilities in 1967 (table 6), the total hours of labor on Lake States farms producing milk was just over 1 billion hours. Table 7 shows a breakdown of this total by type of worker. Approximately 33 percent of this labor was estimated to be needed for chore labor used directly in the dairy enterprise.

Total hours of labor worked on farms producing milk will decrease an estimated 47 percent from 1967 to 1980. This projection assumes a gradual increase in the number of parlor farms and a marked decrease in the number of total dairy herds (table 6). The proportion of the labor decrease that will leave agriculture completely is unknown. However, this decrease is accounted for by over 70,000 farm operators and their families leaving dairy production and by the adoption of substantially more labor-saving technology.

The estimates of total hours of labor are approximations but they provide an estimate of the total labor needs of farms producing milk in the three Lake States.

Seasonal distribution of labor

Total labor used on the average farm selling milk varied considerably by months of the year primarily because crop enterprises required extra summer labor. The seasonal variation of labor use was more marked on farms using milking parlors than on farms using stanchion barn facilities (fig. 7). This difference probably is accounted for by the fact that parlor farms used relatively more seasonal hired labor for the

Table 6. Estimated present and projected number of farms using milking parlors and conventional stanchion barn housing, Lake States, 1967, 1975, and 1980

	Number of farms		
	1967	1975	1980
Parlors	4,434	5,930	6,571
Stanchion barns	141,412	87,768	69,216
Total farms	145,846	93,698	75,787

Table 7. Present and projected employment potential on farms producing milk, Lake States', 1967, 1975 and 1980.

	1000 hours		
	1967	1975	1980
Operator	523,547	337,234	273,279
Wife	126,262	80,177	64,309
Unpaid family	242,502	155,868	126,116
Regular hired	55,529	36,966	30,610
Seasonal hired	67,826	47,025	40,024
Total	1,015,660	657,270	534,338
Percentage change in total from 1967		-35%	-47%
Percentage of total for feeding and handling dairy cows	33%	39%	42%

Total hours: 8462

	Percent of total
Operator	45.8
Wife	6.7
Unpaid family	19.9
Regular Hired	9.3
Seasonal Hired	18.3

Total hours: 6917

	Percent of total
Operator	51.8
Wife	12.7
Unpaid family	24.0
Regular Hired	5.3
Seasonal Hired	6.2

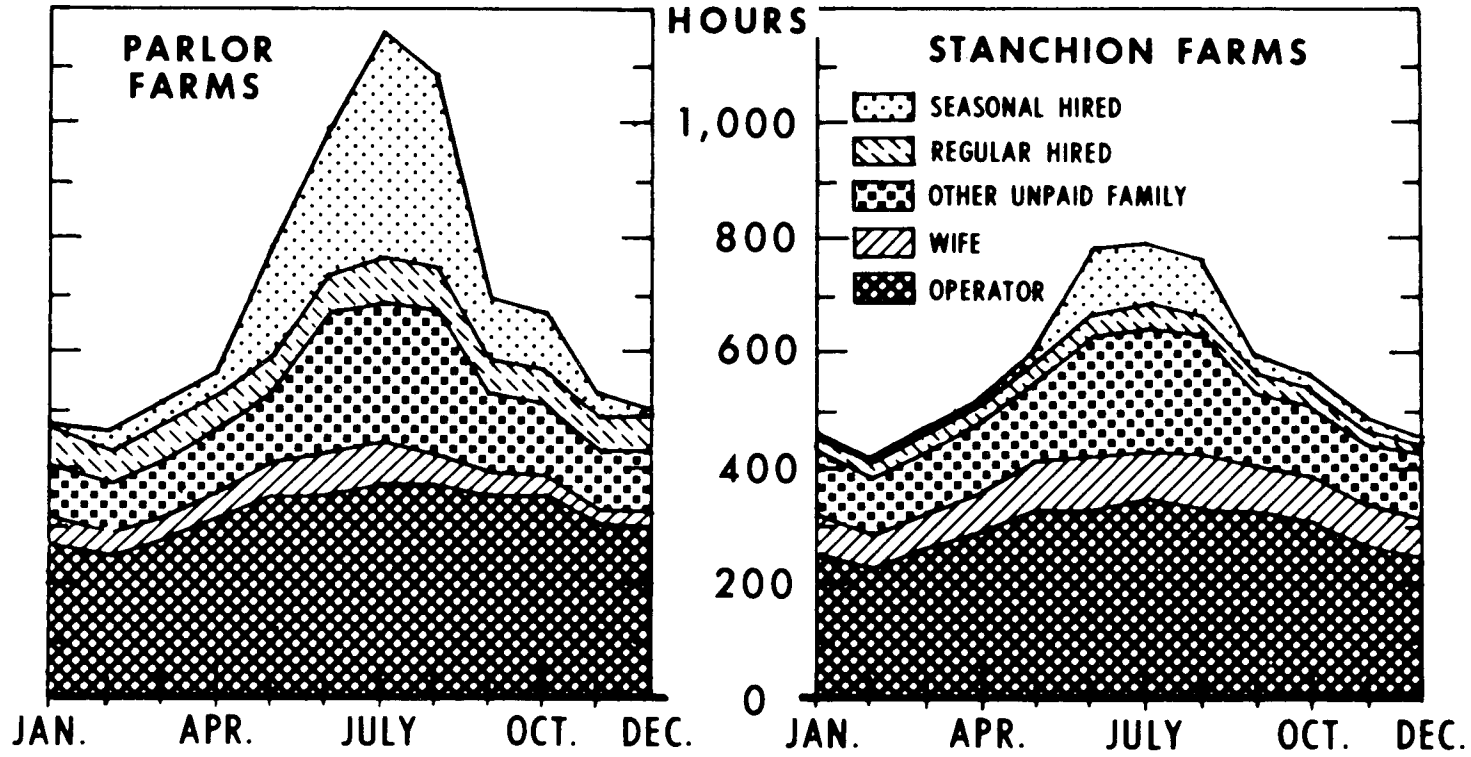


Figure ". Average seasonal distribution of labor used on farms reporting milk sales by stanchion and parlor technology - Lake States region, 1964.

cropping activities. The amount of seasonal hired labor varied from one hour in January to almost 400 hours in July on the average farm using the milking parlor. For stanchion farms it varied from 3 hours in January to only 116 hours in June. In total, the average parlor farm used more than three times as much seasonal hired labor as the average stachion farm (table 5).

The projected increase in the proportion of farms using milking parlors, therefore, will increase the importance of seasonal hired and regular hired labor relative to the labor contributed by the operator, his wife, and unpaid family. Even though hired labor will become relatively more important on dairy farms, the absolute amount needed will decrease (table 7).

The seasonal distribution of labor will become more pronounced by 1975 and 1980 because of the projected increase in importance of farms with milking parlors and the accompanying increase in seasonal hired labor. The increased labor requirements per farm will be met primarily by increasing the use of seasonal hired labor and, for some larger farms, by increasing regular hired labor. Hours worked per farm by the farm operator, his wife, and family are expected to remain about the same since they are almost fully employed already. However, the survey shows that farmers using milking parlors work slightly more hours than farmers using stanchion barns. The implication is that operators and their families will work slightly more hours on the average as a larger proportion of herds is milked on larger milking parlor farms.

The changes expected in seasonal distribution of total labor due to the projected changes in the number and sizes of dairy herds and greater use of laborsaving technology in dairy farming will be minor. The most marked change will be the decrease in total labor employed (fig. 8).

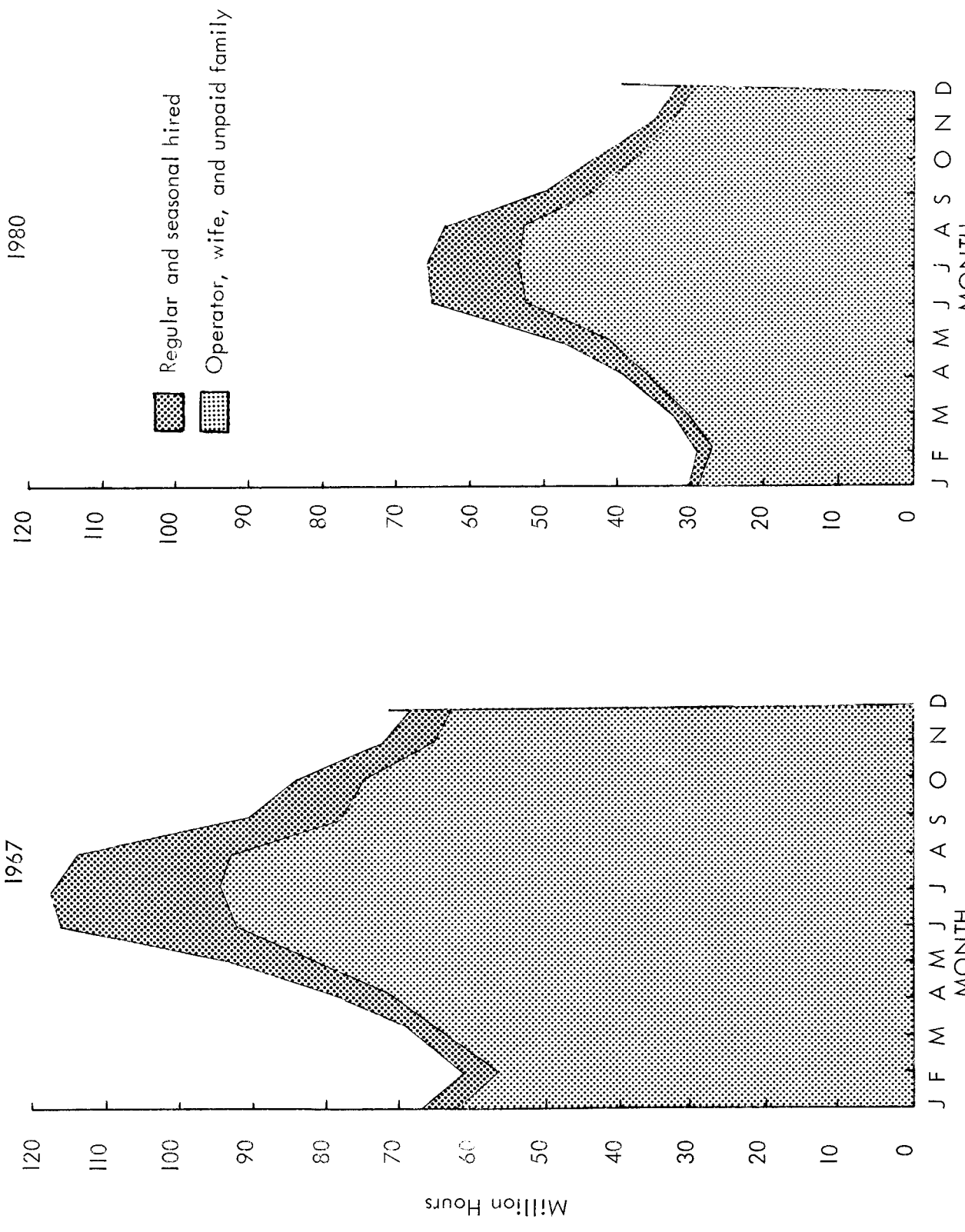


Figure 8. Estimated seasonal distribution of all labor used on Lake States farms with dairy cows, 1967, and projected to 1980.

Summary and conclusions

This study projects to 1975 and 1980 the changes in total labor needs of dairy farming in the Lake States. These projections explicitly take into account past changes in the number and sizes of dairy herds and the adoption of laborsaving dairy technology.

Labor used for feeding, caring for, and milking dairy cows is expected to decline from an estimated 333 million hours in 1967 to 222 million hours in 1980. During the same time, labor per cow is expected to decline from 95 to 80 hours annually, and labor per cwt. of milk is expected to decline from 1.0 to 0.66 hours. These changes are projected even though total milk production in the Lake States is expected to remain about constant. The decline in dairy chore labor alone will represent 53,000 fewer man equivalents of labor annually.

By 1980 only about 76,000 farm operators and their families, or 73,000 fewer than in 1967, will be involved in dairy production. The total hours worked by the operators, their wives, unpaid family, and regular hired and seasonal hired workers are expected to decline 33 percent by 1975 and 47 percent by 1980. The decrease in the number of farm operators involved in dairy production represents both opertors who will leave agriculture through retirement or shift to nonfarm work and those who will continue farming but shift to nondairy enterprises.

In total, labor used by both farm families and hired labor will decrease substantially by 1980. However, hired labor will become

relatively more important compared with operator and family labor. The seasonal use of labor will become somewhat more marked by 1980 due to the greater proportion of larger herds which typically use more seasonal hired and regular hired labor than smaller herds on stanchion farms.

The number of dairy cows in many Lake States counties has not decreased as rapidly as in other counties causing a relative shift in the concentration of dairy production. 5/ In general, the northern counties in each of the states had large decreases in dairy cows. Also densely populated counties and counties with flat, productive land have left dairying at a faster rate.

No attempt was made in the report to estimate either the demand curve for dairy labor or how this curve is likely to shift over time. Rather the quantities of labor required over time (given the projected changes in technology and numbers and sizes of herds) represent equilibrium quantities of labor. The wage rate necessary to bring forth the supply of labor to meet the dairy labor requirements is assumed to exist, but no effort was made to identify this wage rate. Because projections are based primarily on past trends, this study assumes that the labor market conditions that influenced the labor used in dairy over the base period 1960-1969 will continue to 1975 and 1980.

5/ Only two counties in the Lake States region had more dairy cows in 1968 than in 1960.

APPENDIX A

Chore labor

Technology used on Lake States farms in 1967 to feed, care for, and milk dairy cows was estimated from a sample survey of all farmers selling milk. 6/ From this survey, 15 dairy systems or ways of feeding, caring for, and milking dairy cows were identified on the basis of differences in labor inputs. 7/ The proportion of farms in each of five herd size groups (1-9, 10-19, 20-29, 30-49, and over 50 ccws) using the 15 dairy technologies were estimated from the survey results.

Given five herd size groups and 15 technology systems, the total chore labor for 1967 was estimated by using the following expression:

$$\text{Dairy chore labor} = \sum_{j=1}^{5} \sum_{i=1}^{15} t_{ij} \, S_j^{(1967)} \, (F_i + V_i \bar{X}_j)$$

where

j = herd size group

i = technology system of feeding, caring for, and milking the dairy herd

t_{ij} = the proportion of herds in the j^{th} size group using the i^{th} technology system for handling dairy cows

$S_j^{(1967)}$ = number of herds in the j^{th} size group in 1967

F_i = annual fixed labor of the i^{th} system in hours per year

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6/ This dairy technology survey is summarized in appendix B.

7/ Labor inputs for alternate technologies were obtained from secondary sources. (appendix E).

V_i = annual variable labor per cow using the i^{th} system in hours per year [8/]

$\bar{X}_j$ = average number of cows in the j^{th} herd size group

Future dairy chore labor was estimated by projecting the number and size distribution of dairy herds to 1975 ($S_j^{(1975)}$) and to 1980 ($S_j^{(1980)}$) and recomputing the above expression.

The implied assumptions are:

1. Herds that enter or leave a given size group over time will have the same proportion of herds using each of the 15 systems as estimated for the entire size group in 1967. That is, the t_{ij} will remain constant to 1980.
2. The fixed (F_i) and variable (V_i) labor for all 15 systems will remain constant to 1980.
3. The average number of cows in each herd size group ($\bar{X}_j$) will remain constant to 1980. This was assumed also for herds with over 50 cows. [9/]
4. The technology represented by the 15 systems will still be the primary technology used in 1980 dairy production (ranging from unmechanized stanchion to mechanized parlor farms).

8/ For a further explanation of the fixed and variable labor concept see appendix E.

9/ From 1955 to 1967, the average number of cows on Minnesota farms having more than 50 cows did not increase but varied slightly around 63.7 cows per herd. Source: Minnesota Crop and Livestock Service, St. Paul, Minnesota. Unpublished data.

APPENDIX B

Total hours of labor worked on farms producing milk was estimated in the following way:

$$T^{(1967)} = 6{,}917\ C^{(1967)} + 8{,}463\ P^{(1967)}$$

where

T = total labor used (dairy and nondairy enterprises)

$C^{(1967)}$ = total farms using conventional stanchion barn facilities in 1967

$P^{(1967)}$ = total farms using loose housing and milking parlor facilities in 1967

6,917 = total hours worked on an average stanchion barn farm per year by the operator, wife, unpaid family, seasonal hired and regular hired workers (1964 data)

8,463 = total hours worked on an average parlor farm per year by the operator, wife, unpaid family, seasonal hired and regular hired workers (1964 data).

The projected total labor is based on the projected number of stanchion farms $\left[C^{(1975)} \text{ and } C^{(1980)}\right]$ and parlor farms $\left[P^{(1975)} \text{ and } P^{(1980)}\right]$.

APPENDIX C

Milk production practices in the Lake States - 1967

During May and June of 1968, a questionnaire on milk production practices was mailed to a stratified random sample of farms shipping milk to creameries. 10/ The survey was taken in the three Lake States -- Minnesota, Wisconsin, and Michigan. Information obtained was for the year ending December 31, 1967.

The survey excludes the farms where the owner uses the milk for home consumption only. Also some farms selling milk on a very irregular basis may be excluded from and not represented by the sample.

The results of the survey are presented in the following tables. On some questionnaires the information was either missing or did not apply to that particular farm. Therefore, the number of farms on which each item of information is based is shown in parentheses under the item. Estimates for the Lake States are obtained by weighing the individual state estimates.

10/ The list of milk shippers included those whose herds had recently been tested for brucelloisis by Animal Health Division, Agricultural Research Service, U.S. Department of Agriculture. Tests are conducted four times a year.

Table C-1. Percentage of farms with milking parlors and type of milking parlor, Lake States, 1967.

	Minnesota	Wisconsin	Michigan	Lake States
Percentage of all farms shipping milk	2.5 (536)	1.8 (615)	11.8 (572)	3.3 (1,723)
Percentage of farms with parlors by type of parlor*				
Herringbone	20	18	35	21
Walk through	31	7	15	17
Side opening	40	75	45	58
Other	9 100 (15)	0 100 (14)	5 100 (73)	4 100 (102)

*Percentage based on small group of farmers reporting milking parlors.

Table C-2. Type of housing for dairy herds, Lake States, 1967.

	Percent of farms*			
Type of housing	Minnesota	Wisconsin	Michigan	Lake States
Stanchion	90.9	95.5	76.6	91.3
Stanchion -- rotated use	5.0	2.4	9.7	4.3
Loose -- conventional	3.3	1.8	12.0	3.7
Cold free stall	1.7	1.5	9.4	2.6
Warm, enclosed free stall	0.6 101.5 (525)	0.5 101.7 (612)	0.6 108.3 (566)	0.5 102.4 (1,703)

*Totals add to more than 100 because some farms reported more than one type of housing.

Table C-3. Methods of conveying milk to storage, Lake States, 1967.

	Percent of farms			
Method	Minnesota	Wisconsin	Michigan	Lake States
Pipeline	4.2	7.7	12.6	6.9
Milk transfer	10.4	11.9	13.1	11.5
Carry by hand	85.4	80.4	74.3	81.6
	100.0	100.0	100.0	100.0
	(509)	(605)	(555)	(1,669)

Table C-4. Method of manure disposal, Lake States, 1967*

	Percent of farms			
Method	Minnesota	Wisconsin	Michigan	Lake States
Handloading into spreader	50.5	32.9	38.8	40.6
Gutter cleaner	30.8	56.1	29.4	42.8
Tractor scraper and loader	3.9	5.4	22.9	7.0
Litter carrier	15.9	8.8	4.2	11.0
Tractor loader	18.1	12.1	25.2	16.1
Liquid manure system	0	+	1.2	0.2
Other	1.0	0.5	2.3	0.9
	120.2	115.8	124.0	118.6
	(533)	(608)	(567)	(1,708)

*Totals add to more than 100 because some farms reported more than one method.

+One farm reported a liquid manure system.

Table C-5. Farms reporting cows being pastured and average number of weeks cows were pastured, Lake States, 1967.

	Minnesota	Wisconsin	Michigan	Lake States
Percent of farms reporting pasture	83	90	79	86
Percent of farms reporting no pasture	17	10	21	14
	100	100	100	100
	(503)	(563)	(495)	(1,561)
Average number of weeks cows were on pasture*	19.0	20.8	19.3	19.9
	(415)	(494)	(379)	(1,288)

*Of farms reporting pasture.

Table C-6. Method of storing and feeding corn silage, Lake States, 1967.*

			Percent of farms	
Method	Minnesota	Wisconsin	Michigan	Lake States
Upright silo, hand unloaded, and distributed with cart	59.0	66.0	63.4	62.9
Upright silo, mechanically unloaded, and distributed with cart	29.9	29.7	18.3	28.3
Upright silo, mechanical unloader and feed bunk	5.3	10.6	17.9	9.4
Bunker silo	16.7	1.9	10.0	8.8
	110.9	108.2	109.6	109.4
	(400)	(498)	(396)	(1,294)

*Totals add to more than 100 because some farms reported more than one method.

APPENDIX D

The Markov chain technique

The Markov chain technique has been used widely in the analysis of firm size distribution in and out of agriculture. In this study, the technique was used to project to 1975 and 1980 the number of dairy herds in each of the five herd-size categories. The basic concept underlying the technique is that the movement of herds between size groups and entering or exiting from dairy production over a base period is used to estimate the probabilities that herds in each size group either will remain in the same size groups, move to different size groups, or their owners will leave dairying in the future. Hence, the movement of herds between size groups and out of dairying is considered a stochastic or probability process. 11/

The ideal information regarding the movements of herds between size groups is to follow the movement of each individual herd over the base period. The proportion of herds in each size group that discontinues dairying, moves to each different size group, and remains in the same size group during the base period can then be identified and used as probable future movements of herds between size groups. This type of information is not available in the Lake States. However, the state census data which report the annual net changes in the number of herds in each size group can be adapted to the Markov chain technique if the following assumptions are made:

11/ A description of the Markov chain technique is made by Ronald D. Krenz in "Projections of Farm Numbers for North Dakota with Markov Chains," Agr. Econ. Res., USDA, Vol. 16, No. 3, July 1964, pp. 77-83.

1) Dairymen more likely will increase than decrease their herd sizes because of economies of size and the pressure many feel to increase the output volume.

2) Dairymen are more likely to discontinue dairying than to decrease their herd size. Their likely responses would be to drop the dairy enterprise from the farm organization in favor of nondairy enterprises rather than decrease the dairy herd size. Also many dairymen are leaving agriculture completely because of retirement or good off-farm opportunities.

3) The movement to larger herd size groups probably will be gradual because of capital limitations. Probably few dairymen would be able to jump two size groups in any 1 year.

The annual census data on the number and size distribution of dairy herds for Minnesota and Wisconsin are shown in tables F-1 and F-2. Markov chain projections were made for both states using 1960-1969 as the base period.

Annual data on the number and size distribution of dairy herds were not available for Michigan. Therefore, the Markov chain technique was not used as a basis for projecting the number and size distribution of dairy herds in that state. The United States Census of Agriculture, 1959 and 1964, combined with projections made by Michigan State University and least squares projection of cow numbers served as a basis for the Michigan projections.

The accuracy of the Markov chain technique in projecting the future movements of dairy herds depends on whether the basic conditions that brought about the movements over the base period will continue into the future.

APPENDIX E

The chore labor routine was divided into 10 chore tasks as follows: 12/

1. milking,
2. cleaning and preparation of milking utensils,
3. hay feeding,
4. silage feeding,
5. grain feeding,
6. manure handling,
7. bedding,
8. other routine work,
9. care of dairy cattle not in stanchions, and
10. miscellaneous labor (feed grinding).

Secondary sources supplied estimates of the hours of labor per cow per week for the summer, winter, and supplemental feeding seasons when alternative technologies are used. Labor used for each task was estimated as the amount of fixed labor, not varying with the number of cows (such as cleaning the milking utensils), plus the labor used for each additional cow in the herd (such as the acutal milking). Total labor used per year per herd for a particular technology system was obtained by adding the labor for all chore tasks and summing for the three seasons of the year.

12/ Fuller, Earl I., and Harald R. Jensen, "Alternative Dairy Chore Systems in Loose Housing," University of Minnesota, Agr. Exp. Sta. Bull. 457, Feb. 1962, pp. 34-40.

Therefore, labor inputs for each of the 15 technology systems were expressed as follows:

$$\text{Total chore labor} = F + VX$$

where

F = total fixed chore labor per herd

V = chore labor for handling one additional cow and her replacements

X = number of cows in the herd

For example, total chore labor for the most mechanized system of handling cows (code 15) was estimated to be

$$\text{Total chore labor} = 690 + 42X$$

Therefore, total chore labor for a 40-cow herd using this mechanized technology would be 2,370 hours per year $[690 + 42\ (40) = 2{,}370]$. Total chore labor for the 15 systems is shown in table 1.

APPENDIX F

Table F-1: Number and size of dairy herds in Wisconsin, 1959 to 1969, and projected to 1975 and 1980.

	cows per herd					
Year	1 - 9	10-19	20-29	30-49	50+	Total
1959	16,909	37,970	34,847	11,488	1,126	102,340
1960	15,154	33,438	34,190	12,601	1,313	96,696
1961	13,962	30,449	33,441	13,812	1,548	93,212
1962	12,825	27,339	29,824	17,724	2,283	89,995
1963	11,830	25,051	38,797	18,882	2,574	87,134
1964	10,682	22,471	27,256	20,038	2,959	83,586
1965	10,268	20,793	25,780	20,242	3,299	80,382
1966	9,344	18,295	22,930	19,122	3,312	73,003
1967	8,957	16,477	21,302	19,854	3,804	70,394
1968	8,083	14,937	19,526	19,675	4,068	66,289
1969	7,288	13,217	18,207	19,298	4,436	62,446
Projected						
1975	4,712	7,422	12,061	19,700	6,206	50,101
1980	3,205	4,503	8,532	18,915	7,703	42,858

Table F-2: Number and size distribution of dairy herds in Minnesota, 1959 to 1969, and projected to 1975 and 1980.

	cows per herd					
Year	1 - 9	10-19	20-29	30-49	50+	Total
1959	34,528	38,126	13,496	3,641	380	90,171
1960	30,307	35,642	14,283	4,309	477	85,018
1961	27,162	33,923	15,246	4,983	556	81,870
1962	24,240	32,041	15,863	5,619	719	78,482
1963	21,853	30,200	15,913	6,067	812	74,845
1964	19,248	27,848	16,110	6,888	949	71,043
1965	17,236	25,502	16,147	7,304	1,060	67,250
1966	15,604	22,973	14,655	6,982	985	61,199
1967	13,851	19,850	14,052	7,157	1,129	56,039
1968	11,998	17,251	13,517	8,357	1,555	52,678
1969	10,145	14,653	12,983	9,558	1,981	49,320
Projected						
1975	5,666	10,558	11,746	9,308	2,096	39,374
1980	3,241	7,116	10,032	10,096	2,772	33,257