MINNESOTA'S LIVESTOCK INDUSTRIES:
PAST, PRESENT AND FUTURE STRUCTURAL CHANGE

by

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This report is about Minnesota's livestock industries. These industries, like the national ones of which they are a part, have experienced considerable change over the past several decades. The changes have been in response to changing economic, sociological, environmental and political conditions. The focus of the report is on structural change in livestock production, processing and marketing. The main elements of structural change are firm numbers, sizes, and location, the degree of specialization, ownership patterns, and industry entry and exit barriers.

The forces influencing structural changes in the nation's and in Minnesota's livestock industries occur at several levels. Broadly, changes in consumption patterns and demand for livestock products and changes in processing industries exert influence back to the farm level to prompt changes there, but changes in the farm sector itself can also influence changes in marketing and processing industries. Additionally, conditions in the national economy and in the economies of local rural communities can promote or dampen structural change.

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Consumption of Livestock Products

Per capita consumption of all meats has increased fairly steadily in the post war period. Until the early 1970s, per capita consumption of both red meats and poultry was increasing, but in the past two decades, increasing consumption of chicken has been largely responsible for the continuing rise in per capita meat consumption. Health concerns and the growing consumer demand for convenience in food preparation have been influential in fostering changes in the cuts or types of meats consumed.

Dairy products also provide a clear illustration of changing consumption habits. Whole milk and butter have declined in popularity since the 1940s, while consumption of low fat milk has climbed steadily since the end of the 1950s. Cheese consumption has also grown dramatically over the same period, bucking the trend toward lower fat foods.

Consumer concern about health and diet have been important in shaping consumption patterns, but other factors have also played a part. Changing relative prices of the various products and whether they are substitutes for or complements to each other influence buying patterns, as do rising consumer incomes. Demographic factors that have been important are household size, population age and ethnic structure, education levels, employment patterns and the popularity of food prepared, and often consumed, away from home.

Processing and Marketing of Cattle, Hogs and Sheep

The changes in livestock processing and marketing have gone hand-in-hand with changes in demand, technology, transportation and livestock production patterns. Modern slaughtering plants tend to be larger and more specialized than the older ones. They are located, not close to population centers and terminal markets, but in the areas where production is concentrated. The changing patterns are seen clearly in the changes in marketing channels,
with fewer animals moving through public terminal markets and more being sold directly to packers or their representatives.

The total volume of cattle slaughtered in the United States has been fairly stable since 1960, although down from the 1976 peak. The Upper North Central states lost ground in cattle slaughtering between 1968 and 1986, with their share dropping from about 25 percent to below 15 percent. Minnesota, however, has had a fairly stable slaughter volume and in the 1980s regained some of the share of the region's total cattle slaughter that it had lost in the preceding two decades.

The trend in hog processing in the region stands in clear contrast to that for cattle. The Upper North Central states lead the country in hog production and have a strong and strengthening position in hog slaughtering. By 1989, almost 40 percent of the nation's total hog slaughter took place in plants in the region. Minnesota, despite a relatively stable slaughter volume, has lost ground within the region.

Calf, and sheep and lamb slaughter is declining nationally, as consumption of veal, lamb and mutton falls. The region experienced a small boom in sheep and lamb slaughtering in the early to mid-1980s, when it captured about 25 percent of the nation's total sheep and lamb slaughter, but it has since dropped back. Minnesota leads the region in sheep and lamb slaughter, with 30 percent to 40 percent of the total. The region has steadily lost ground in calf slaughtering.

Most livestock slaughter in the United States occurs in federally inspected (FI) plants and the number of FI plants has been dropping, nationally, for all species as plant capacity has been increasing. The average slaughter volume in FI hog and cattle plants in the Upper North Central region is higher and has been more variable than in the United States as a whole, due largely to slaughtering in Iowa, which has both large plants and a large share of the region's cattle and hog slaughter. Federally inspected plants in Minnesota are smaller and their volume less variable than the average for the region.
Overall, the region is fairly well served by slaughtering plants within its borders and in adjacent states, even though, with the exception of sheep and lamb slaughter, production in the region exceeds processing capacity. Southern Minnesota has reasonably good access to steer and heifer and hog plants, both in that part of the state and in surrounding states, but cattle and hog producers in the northern and eastern parts of the state may be disadvantaged by high transportation costs. The region, and Minnesota especially, have been net importers of sheep and lambs for slaughter since the early to mid-1980s.

Farm Level Trends in Minnesota
The set of trends at the farm level have followed a similar pattern in Minnesota, the Upper North Central states and the United States as a whole. Farm numbers have declined and the average size has increased. In Minnesota, the total amount of land in farms, however, has dropped only very slightly since 1935.

Cattle numbers, across enterprises--dairy, beef cows and fed cattle,--have declined in Minnesota since the 1970s and there are fewer farms with cattle enterprises. The number of fed cattle, although clearly down from its 1970 peak, fluctuates and may be stabilizing.

Hog production in Minnesota has not experienced the same drop that cattle production has, even though the number of farms with hogs has declined, from more than 50 percent of all farms in 1950 to 17 percent of all farms in 1990. Total hog production has remained much the same over the 1930 to 1990 period, despite some fluctuation from year to year. The number of piglets per litter has grown steadily, if not dramatically.

The number of stock sheep has dropped considerably from its peak of more than one million head in the early 1940s, but in the 1980s the decline levelled somewhat. There has been a gradual increase in the number of lambs saved per stock sheep, and
marketings at times exceed the number of sheep saved as sheep are imported from other states.

Egg production in the state and the number of layers on farms have dropped, but as the number of eggs per hen has more than doubled since 1943, the drop in total egg production has been muted. Broiler and turkey production has expanded considerably. The number of birds per farm has increased dramatically since the 1970s and has more than compensated for the decline in the number of farms raising broilers and turkeys.

Economic measures of productivity or profitability, such as total economic costs and residual returns to management and risk, show a fairly similar pattern across the country for farms of different sizes: smaller operations generally have higher costs and lower returns than do larger ones.

Minnesota and the Upper Midwest have lost ground to other regions of the country in milk and cattle production, as costs here have escalated faster than they have elsewhere. For milk production, costs per hundredweight of milk are lowest in the Pacific region.

Costs per cow for cow/calf operations are lower in the Great Plains and the West than they are in the North Central and Southern states. Even so, negative residual returns to management and risk are common in cow/calf operations across sizes and regions. In cattle feeding, considerable year-to-year variation in residual returns is evident for operations of all sizes, but the gap between farmer lots--characteristic of many Minnesota cattle feeding operations--and larger commercial lots has widened as returns for farmer lots have become more negative.

In hog production, the same general trend applies: smaller operations have higher costs and lower returns than do larger ones. The North Central region has lower total economic costs per hundredweight and higher returns for farrow-to-finish and feeder pig operations, and for finishing pigs in the 1980s, than does the other major hog producing region, the Southeast.
Projections for Minnesota's Livestock Industries

Minnesota's livestock industries have been affected by the various forces that have contributed to consolidation in U.S. agriculture over most of the twentieth century. These forces are expected to continue to act in much the same way, and with generally similar results, as they have heretofore.

The number of farms in Minnesota is projected to continue to decline, while the average farm size continues to increase. Farms with livestock are projected to decline in number more rapidly than farms in general, resulting in more crop and fewer diversified crop-livestock farms in the state.

Cattle production in general is projected to decrease, with the largest projected decrease being in dairy farms. The total number of dairy cows and total milk production is expected to drop, although the average herd size is projected to increase slightly and production per cow will continue to go up. The general story is similar for beef cow/calf operations: fewer cows in total and a slightly larger average herd size. In beef cattle feeding, although the general direction is downward, a stable trend is not yet discernable.

Minnesota's hog industry is projected to grow, despite a projected decrease in the number of hog farms. All other production measures are projected to rise: the number of sows producing a litter; the average number of sows per farm; piglets per litter; and total pig crop.

Projections for the state's sheep industry show the decline in numbers continuing, although more slowly than in the 1960s and 1970s. All measures except the number of lambs saved per stock sheep are projected to decline.

In poultry production, commercial broiler and turkey numbers are projected to increase. The total number of layers will continue to drop, as will total egg production in the state, but it will be dampened a little by a projected increase in the number of eggs per hen.
Some Possible Alternative Scenarios

The projections above are based on the expectation that there will not be a major deviation from recent trends in the main forces that drive conditions in the state and national livestock industries. Should such a deviation occur, the outlook for those industries could be quite different.

Some shifts from recent trends are possible, if not probable, in the next five to ten years. The national economy could face a more prolonged period of recession or growth than has been typical in the last two decades. Consumer tastes and preferences could change more sharply, as more people become concerned about diet and health and as the demand for services associated with food products rises. Regional population shifts could become more pronounced. The level of government intervention in agricultural markets could change. Technologies important in food production, processing and marketing could become more readily available, or the rate of technological change could slow, compared to that in the past five years. Public concerns about agricultural production and processing methods and practices could escalate more rapidly than expected, and many more regulations on these practices could be put in place. International economic, social or political conditions could become more unstable, giving rise to the very real possibility of serious regional food shortages.

No probability can be attached to such events and trends, except that they are considered, at this time, to be less probable than a continuation of recent trends. They, and their implications for the U.S. agricultural sector, are all too important, however, to be ignored or overlooked completely.

Future Research Needs

Four general areas stand out as needing more information in the near future if we are to understand the changes that are occurring, and will likely continue to occur, in Minnesota's...
livestock industries. The first area is that of production costs, particularly comparisons of costs for operations of different sizes and in different regions of the country. The second area is livestock processing. Questions of optimal plant sizes and locations for beef, dairy and poultry plants especially need to be examined. Management options for beef (particularly cow/calf operations) and hog operations in Minnesota and the Upper North Central region is the third area in which more work is needed. And finally, the vast topic of new products from and new uses for agricultural commodities raises a great many questions that will be of relevance to the livestock industries of Minnesota, the Upper North Central states and the nation in the coming years.

Concluding Comments

There are several conclusions to be drawn from this study. One is that the broad trends in consumption, processing and production in the livestock industries in general point to, at best, slow growth or, more likely, a stable or declining trend for these industries in Minnesota. Two possible exceptions to the general trend are the hog and poultry industries. The second conclusion is that while the trends apply to the industries as a whole, there will always be individuals who buck a declining trend. To the extent that the citizens of Minnesota want to have viable state livestock industries, it is those individuals, who are prospering, who need to be encouraged and from whom we can learn.
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I. INTRODUCTION

Minnesota's livestock industries have experienced major changes over the past few decades. The pattern of change has been generally similar across species: farm numbers have decreased, the remaining farms are larger, and production per animal unit has increased. The total numbers of dairy and beef cattle in the state have decreased, as has total milk production. The number of layers has also declined and egg production has leveled off in the last two decades. Hog, sheep, broiler and turkey numbers have increased and these industries are stable or growing. Many of the broader trends, in farm numbers, farm size and production per animal for example, characterize not just Minnesota's livestock industries, but those of the Upper North Central region (of which Minnesota is a part) and of the United States as a whole. These changes have come in response to a number of forces and their impacts reach into many other parts of the economy and society. And there is every reason to expect further changes in the future.

This report focuses on the structure of Minnesota's livestock industries and the factors that influence and are affected by changes therein. There are several facets to the concept of industrial structure. The most obvious elements are the number, size distribution and regional location of firms. The degree of specialization in a particular livestock production enterprise is also important, as it provides an indication of the reliance on one set of markets by a firm, region, or state. Another facet is the pattern of ownership, or control, of productive resources. Institutional and financial barriers to entry to and exit from an industry are also aspects of structure,
as are the socioeconomic characteristics of farm operators and resource owners.

Structural change is a two-way street. Many factors that contribute to changing structure in the agricultural sector are in turn themselves influenced by structural change. The following factors are often suggested as having important influence on farm sector structure: changes in relative farm input prices; technological change; size economies; government policy; the state of the general economy; changes in upstream and downstream industries; changes in rural communities and in supporting infrastructure; regional comparative and competitive advantage; consumer tastes and preferences; environmental and health considerations; and resource endowments.

The past and potential future changes in the structure of Minnesota's livestock industries have affected, and will continue to affect, a wide spectrum of Minnesota's citizens. Livestock producers will continue to face the challenges of meeting an ever evolving market and trying to make a profit while doing so. Processing industries and input suppliers will continue to be concerned with changes in the level and location of demand for their products and services. Changing consumer tastes and preferences will remain one of the key driving forces behind changing demand for animal products, and consumers will, at the same time, be interested in how any structural changes in the state's livestock industries may affect the quantity, quality, safety, healthfulness and cost of their food supply. Rural communities may well face changes in farm numbers and types, in employment opportunities and in income levels, and will be concerned about the impacts of these changes on the demand for the goods and services they supply. And elected officials will look at the general effects of structural changes in many agricultural industries on the welfare of the state's citizens in terms of the health of the economy and the quality of life in Minnesota.
This report provides background information on some of the major changes occurring in the livestock industries in Minnesota, in the Upper North Central region and in the United States, and offers some ideas as to what the future might hold for those industries. It focuses on changes, first in livestock product consumption patterns, then in the red meat processing industry, and third at the farm level. The final sections consider possible events and phenomena that could alter the outlook for the industries and highlight the conclusions drawn from the study.

II. TRENDS IN AND FACTORS AFFECTING CONSUMPTION OF LIVESTOCK PRODUCTS

Livestock consumption patterns have changed considerably over the past fifty years. Overall consumption of meats, dairy products and eggs grew substantially in the forty years before 1980, but it has slowed in the last decade. The mix of products consumed has also changed, but recent data show no stabilization as yet. These changes have occurred for a number of reasons, including health considerations, changes in relative prices and incomes, and changes in the demographic composition of American society.

U.S. income has reached a level where demand is now less responsive to income growth than it was earlier in this century. In addition, U.S. population growth appears to be slowing. These two factors combined, create a situation in which the livestock industry can no longer expect to see an ever increasing rate of growth in demand for its products.

In looking to and preparing for the future for Minnesota's livestock industries it is pertinent to look first at the

1. The material in this section is drawn extensively from Jorunn Grande, Changes in the Consumption of Livestock products: Trends, Influential Factors and Future Projections, unpublished Plan B Paper, submitted to the Graduate School of the University of Minnesota, June 1991.
historical trends of livestock product consumption in the United States and the main factors influencing them.

A. Trends in Consumption of Livestock Products

As noted above, consumption patterns for livestock products have changed substantially since early in this century. In 1909, red meats accounted for about 90 percent of the almost 150 pounds of meat consumed by an average citizen\(^2\). Beef and pork were the main meats in the American diet, accounting for about 80 percent of the total, while veal and lamb and mutton together accounted for less than 9 percent. Chicken and a very small amount of turkey made up the remaining share of meat consumption. The combined share for beef and pork remained high through the middle of the century, when poultry began to pick up shares that the principal red meats were losing. Figure 1 illustrates the change in consumption patterns over the past eighty years. By 1989, chicken, beef and pork together accounted for 90 percent of the total meat consumption of almost 220 pounds per capita and the shares were evenly distributed among these three meat types. The rapid growth in poultry consumption has been the main factor contributing to the overall increase in meat consumption, since about 1970 (Figure 2).

The average, annual per capita consumption of all red meats dropped from almost 134 pounds in 1909 to a low in 1935 of 101 pounds and then increased to a peak of almost 157 pounds in 1971. The popularity of red meat has been declining since then and by 1989 the average annual per capita consumption was the same as it was in 1909. By 1989, red meats represented only about 61

\(^2\) Both per capita and total consumption figures are based on disappearance data. Disappearance is defined as the total amount of a commodity that disappears into the market, whether or not it ends up being consumed by humans. Disappearance is easily monitored and recorded at both the national and regional levels. Actual consumption surveys are conducted only at irregular intervals and only on population samples.
Figure 1. Changing meat consumption patterns
Percentage share, various years

1909
Beef 39%
Sheep 8%
Chicken 10%
Pork 42%

1940
Sheep 9%
Chicken 10%
Turkey 1%
Pork 48%

1979
Sheep 1%
Chicken 25%
Turkey 5%
Pork 31%

1989
Sheep 1%
Chicken 31%
Turkey 31%
Pork 29%

Source: Hiemstra (1968) and Putnam (1990)
Figure 2. Total meat consumption
Pounds per capita, by type of meat, 1909 to 1989

Source: Hiemstra (1968), and Putnam (1990)

Figure 3. Beef, pork and poultry consumption
Pounds per capita, 1909 to 1989

Source: Hiemstra (1968), and Putnam (1990)
percent of all meats consumed (not including edible offal), compared to almost 76 percent in 1970.

Beef's relative share of total meat consumption has been fairly stable, around 38 to 39 percent in most years, although it slipped as low as 31 percent in 1940 and 1989. The pattern of per capita beef consumption has been similar to that of red meats in total; average annual consumption was almost 59 pounds in 1909, it dropped to a low of 37 pounds in 1932, then rose to a peak of just over 94 pounds in 1976. It has been declining over the past fifteen years and stood at about 68 pounds in 1989. The record high in 1976, when Americans consumed a total of 20.6 billion pounds of beef, may be attributed to the liquidation of the nation's beef herd that year, which brought prices down, stimulating demand (Putnam, 1990).

In terms of the amount of meat consumed, pork consumption per capita has been fairly stable over the period, although there have been quite large year-to-year fluctuations, and there is some evidence to suggest that it may now be increasing. Annual per capita consumption of pork in 1989 was almost the same as it was in 1909, about 62.5 pounds. In terms of shares of the total amount of meat eaten, however, pork has lost ground, declining from 42 percent in 1909 to 28 percent in 1989. Although total disappearance of pork was at its highest level in the 1980s, with total consumption of pork reaching almost 16 billion pounds in 1988, per capita consumption peaked in 1943/1944 at about 74 pounds.

Veal and sheep meats—lamb and mutton—account for the smallest shares of total meat consumption and their combined share has been diminishing over the years, falling from about 13 pounds per capita in 1909, almost 8.5 percent of the total meat consumption, to less than 3 pounds per capita (1.2 percent of the total) in 1989. Neither veal nor sheep meat consumption followed the upswing in meat consumption in the 1950s and 1960s. Consumption of these meats has declined since the 1940s, with veal enjoying a slight and short-lived reprieve in the mid-1950s.
Buse (1989) attributes the general decline in per capita red meat consumption since the mid-1970s mainly to a decline in the use of less expensive steaks, bacon, sausage and variety meats. Some of this decline was, however, offset by increased consumption of ground beef and more expensive steaks. In the case of pork, fresh pork consumption has increased while the consumption of other pork products has decreased.

Poultry's relative share of total meat consumption and its annual per capita consumption have both increased enormously since the early 1900s. In 1909, Americans ate an average of less than 15 pounds of chicken per year; by 1970 consumption had increased to 40 pounds. Per capita chicken consumption has exceeded that of pork since 1986 and, at 68 pounds in 1989, was almost equal to beef consumption (69 pounds). Combined per capita poultry consumption exceeded per capita beef consumption in that year (Figure 3).

Although turkey consumption has always been much less than that of chicken, it has increased steadily since 1909. Annual per capita consumption of turkey increased from 1 pound in 1909 to almost 17 pounds in 1989.

A closer look at the poultry industry shows that the increased poultry consumption is partly a result of the growing popularity of cut-up chicken and turkey, at the expense of whole birds, in our seemingly never-ending search for convenience (Buse, 1989). Wohlgenant (1989) suggests that there is some evidence of a high degree of substitutability between hamburger

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3. Some differences in definition should be noted when comparing per capita consumption data for different types of meats. Poultry is measured in ready-to-cook carcass weight, the weight of an entire dressed bird. Beef is measured in retail weight, containing less bone and is relatively lighter than poultry in terms of carcass weight. Therefore, the poultry data may overstate the actual amount of poultry meat consumed compared to the amount of beef consumed, and in 1989 the trimmed equivalent weight of beef consumed was 65.1 pounds, still ahead of poultry at 60.3 pounds. The trend, however, is clear, poultry consumption is heading up while beef consumption is flat or declining.
and poultry. He suggests that changes in the poultry market may affect the composition of beef consumption and the sensitivity of beef demand to poultry prices. The changes in the poultry market that may be of particular importance are the increased number of fast food restaurant chains that serve chicken meals and the changing consumer preferences in favor of poultry due to increased concerns about saturated fat in the diet. The implication of these changes is that decreases in poultry prices may now have a greater depressing effect on the demand for beef than previously.

The changing patterns of consumption of dairy products perhaps serve best to illustrate changing consumer eating habits and dietary preferences. On the one hand we see slowly declining total fluid milk consumption, more sharply declining whole fluid milk consumption and even more sharply declining butter consumption. On the other, there has been an increase in cheese and low fat milk consumption. By 1987, low fat milk consumption, at 114 pounds per capita, outpaced whole milk consumption, at 110 pounds per capita (Figure 4). Together these two trends blur any clear picture as to the current trend in the average consumption of all milk products based on milk fat content. Additionally, the phenomenal rise in breakfast cereal consumption in the United States, an increase of greater than 40 percent in the two decades after 1967, has significantly increased fluid milk consumption and has served to offset the decline in other uses of fluid milk (Smith and Yonkers, 1990).

Much of the drop in consumption of two of the higher fat dairy products--whole milk and butter--is attributed to consumer concern about their intake of calories, cholesterol and animal fats (Smith et al, 1990). The somewhat conflicting picture, illustrated in Figure 5, of increasing cheese consumption--from under 4 pounds per capita in 1909 to 24 pounds in 1987--in the face of these health concerns, may be explained, at least in part, by the prevalence of cheese in many of the foods prepared
Figure 4. Whole and lowfat milk consumption
Pounds per capita, 1909 to 1989

Source: Heimstra (1968), and Putnam (1990)
Note: Reporting system changed in 1970.

Figure 5. Cheese and butter consumption
Pounds per capita, 1909 to 1988

Source: Heimstra (1968), and Putnam (1990)
or consumed, or both, outside the home (Putnam, 1990) and its widespread use as a convenient snack food.

Annual egg consumption increased in the first half of the century, from an average of 345 eggs per person in 1909 to 377 eggs per person in 1951, but has declined steadily since then and in 1989 had fallen to 227 eggs per capita. The decline in egg consumption is generally attributed to concern about cholesterol intake (Putnam, 1990).

B. Influential Factors
As noted above, health concerns are one of the factors influencing changes in the consumption of livestock products. Two other sets of factors have also been influential in these changes. They are economic factors---relative prices and consumer incomes---, and demographic trends.

1. The Responsiveness of Demand to Prices and Incomes
Relative prices and consumer incomes are considered to be the major economic factors behind changing meat consumption patterns. Traditional economic theory tells us that, other things held constant, as a product's price increases, less of the product will be purchased and vice versa for price decreases, and that as their incomes increase, consumers will purchase more, up to some satiation point. Of the total meat expenditures in both 1972/73 and 1986, beef accounted for the largest portion, and pork the next largest, but both these meats lost some ground to poultry over that period. Some of this change can be explained by changing relative prices, in that real poultry prices dropped by almost 25 percent from 1970 to 1984, while the real prices of beef and pork fell by only 14 percent and 18 percent, respectively, over the same period. In the last decade, however, poultry prices have increased relatively more than have the red meat prices, yet poultry consumption has continued its meteoric rise while beef consumption has continued to drop and pork
consumption has remained fairly flat. Later, we will examine some of the reasons behind this change in responsiveness to relative prices.

There is considerable evidence that the responsiveness of the demand for beef, pork and chicken to changes in their own prices, in each others' prices and in consumer incomes have changed over the past decade or so. Estimates by the U.S. Department of Agriculture of the price elasticity, or responsiveness, for beef and chicken indicate that although consumer purchases of these meats are still responsive to price changes, they have become slightly less so in recent years (Haidacher, et al, 1982; Huang, 1985). Consumers continue to be more responsive to changes in beef prices than in chicken prices. Responsiveness to changes in pork prices has remained unchanged, and is somewhat higher than for beef and chicken. Cross price elasticity estimates, measurement of the change in demand for one product in response to a change in the price of another, indicate that chicken and beef are fairly close substitutes, with demand for chicken being somewhat more responsive to changes in beef prices than vice versa. A study by Thurman (1989) suggests that demand for pork and chicken may be independent of each other. Demand for cheese is somewhat less responsive to its own price than are the meats and, interestingly, it is a complement to beef, meaning that an increase in the price of beef decreases the demand for cheese rather than increasing it as occurs for the other meats (Huang, 1985). A partial explanation for this relationship may be found in the rising popularity of combination meat and cheese meals, from cheeseburgers to pizzas to many Mexican and Italian dishes.

Demand for chicken and beef show increasing positive responsiveness to income changes. The response in demand for pork has declined slightly, although it remains higher than that for chicken and only just below that for beef. Cheese demand has a stronger response to income changes than any of the meats.
2. Demographic Trends Influencing Food Consumption

Important demographic factors affecting levels and patterns of livestock consumption are household size, the age composition of the population and its racial and ethnic diversity, education levels, employment patterns, and the popularity of convenience foods and food eaten away from home. Although the precise impact for each of these factors cannot be demonstrated for each livestock product, some interesting patterns are apparent.

For beef, the increasing prevalence of eating out appears to have a positive effect on demand, while decreasing household sizes, an aging population, and greater ethnic diversity— all characteristics of the U.S. population late in the twentieth century— tend to have the opposite effect. In addition, as years of education increase, consumers tend to be quicker to try new foods, more informed about health and food safety issues, to demand higher quality food and food services, and to reduce their red meat consumption.

Poultry demand, while apparently enjoying a similar response to the trend in dining out as does beef, has, unlike beef, benefitted from some of the other changing demographic factors (household size, population age and ethnic diversity). Poultry processors also responded more quickly to consumers' desire for greater convenience in their foods and so have reaped the benefits of that trend.

Like beef, dairy products and eggs will likely see per capita consumption decline with an aging population. Greater ethnic diversity may also have a depressing effect on the demand for dairy products, but possibly a positive effect on egg demand. The increase in food consumed away from home, while possibly having a negative effect on dairy products in general, may have a positive effect on cheese consumption, possibly because cheese is so frequently used as a complement to beef dishes.

Clearly, one of the more important messages that these trends should send to the livestock industries is the importance
of adaptability. As consumers' buying patterns and tastes and preferences change, with rising incomes and education levels, with a changing population in terms of age structure and ethnic background, and with changing household structure in terms of number of occupants and employment characteristics—and the related increases in demand for convenience and the popularity of dining out—so will the demand for the various livestock products change. Producers, processors and marketers will all need to keep their eyes on consumer buying habits and demographic factors and be flexible, adaptable and innovative if they wish to keep pace with these changes and hold onto their share of the consumer's food dollar.

III. CATTLE, HOG AND SHEEP PROCESSING AND MARKETING IN MINNESOTA AND THE UPPER NORTH CENTRAL REGION

Just as consumer demand for livestock products has changed in the past few decades, so have livestock marketing and slaughtering activities. With these changes have come changes in the relative competitive positions of regional livestock industries. Key factors in determining a region's competitiveness are its access to markets and the net farm level price that producers in the region receive for their animals. These factors are greatly influenced by the number, size, type and location of slaughtering plants in the region and by the institutional arrangements covering ownership or control of slaughter animals.

The design and location of livestock slaughtering facilities has changed in the last fifty years. The new generation of plants are single species plants, built on one level, and larger

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4. The information in this section was written by John D. Lawrence and Even Bjornstad and drawn from their publication, Changes in Livestock Marketing and Packing Industries: United States, Upper North Central Region, and Minnesota, Department of Agricultural and Applied Economics, Staff Paper No. P91-19 (St. Paul, MN, University of Minnesota, May, 1991)
in scale and located nearer to the livestock producing regions from whence they draw their input than were the plants they replaced. The older plants were located in population centers, near to terminal markets, and drew livestock from those markets. With the new plants, direct trade between producers and packers has increased and trade through terminal markets has declined.

The considerable changes that have occurred in livestock marketing and processing are at once both a response to and a cause of changes in livestock production. The changes in livestock production will be discussed later. We focus here on livestock slaughtering and marketing in the Upper North Central region, which encompasses Minnesota, the Dakotas, Iowa and Wisconsin, and how these activities have changed since the 1960s.

A. Slaughtering

1. Trends in Slaughtering

The only species for which the total U.S. commercial slaughter volume has increased in the past several decades is hogs. Calf and sheep and lamb slaughter volumes have decreased and cattle slaughter has been fairly flat. Typically, 95 percent or more of all slaughtering in the United States is done in federally inspected (FI) plants. The number of FI slaughtering plants in the United States, in each species category, has been declining fairly steadily since 1975, with a short lived break from trend around 1980 (Figure 6). The Upper North Central states had greater volatility in the number of FI plants in the mid- to late 1970s than did the country as a whole, but since the early 1980s the number of FI plants in the region has been relatively stable (Figure 7).

a. Cattle

For the United States as a whole, annual commercial cattle slaughter has been relatively stable since 1960. It reached a peak of 42.7 million head in 1976, then levelled off as cattle inventories declined. The average volume of cattle slaughtered
Figure 6. Federally inspected slaughter plants, United States, by species, 1975 to 1989

No. of plants

<table>
<thead>
<tr>
<th>Year</th>
<th>Cattle</th>
<th>Hogs</th>
<th>Sheep/Lambs</th>
<th>Calves</th>
</tr>
</thead>
<tbody>
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<td>1989</td>
<td>1,000</td>
<td>700</td>
<td></td>
<td>200</td>
</tr>
</tbody>
</table>

Source: U.S. Department of Agriculture, National Agricultural Statistics Service, Livestock Slaughter, various years

Figure 7. Federally inspected slaughter plants Upper North Central region, by species, 1975 to 1989

No. of plants

<table>
<thead>
<tr>
<th>Year</th>
<th>Cattle</th>
<th>Hogs</th>
<th>Sheep/Lambs</th>
<th>Calves</th>
</tr>
</thead>
<tbody>
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<td>1975</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1980</td>
<td>200</td>
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<td></td>
</tr>
<tr>
<td>1989</td>
<td>100</td>
<td>80</td>
<td></td>
<td>30</td>
</tr>
</tbody>
</table>

Source: U.S. Department of Agriculture, National Agricultural Statistics Service, Livestock Slaughter, various years
in FI plants nationally has been steady or increasing very gradually over the past twenty-five years, rising from 23,900 head in 1975 to 27,400 head in 1989.

In the Upper North Central region, the trend in total commercial cattle slaughtering has been similar to that for the country as a whole, but with a relatively greater increase in the 1960s and a sharper drop after 1976. During the period from 1968 to 1976, farmer feeding in the region was at its height, before much of the cattle feeding activity migrated to large commercial feedlots in the High Plains. As cattle feeding moved away from the region, so packers moved also, closing plants in the midwest and building new ones nearer to the commercial feedlots in Kansas, Texas and Nebraska. Although it was losing its relative importance in cattle feeding, slaughter volume in the region remained relatively high through most of the 1970s as the beef herd was liquidated and a large number of nonfed cattle were slaughtered. By 1989, however, the number of cattle slaughtered in the region had declined to less than 5 million head, down from 8.9 million head in 1976, and even below the 1960 volume of 5.3 million. The region's share of the nation's commercial cattle slaughter has declined, from almost 25 percent in 1968 to 14.4 percent in 1989.

The average annual slaughter volume in FI plants in the region has been both higher and more variable than for the United States as a whole. The higher average is due largely to Iowa's cattle industry. Iowa has both relatively large plants—the average slaughter in 1989 was 151,000 head—and a large share of the region's cattle slaughter—38.2 percent in 1989.

Throughout the 1980s, Minnesota's commercial cattle slaughter volume was very stable and the 1989 figure of 1 million head was typical for the decade, although lower than the peak of almost 2 million head in 1968 (Figure 8). For the two decades prior to 1980, the state lost ground within the region, dropping from almost 27 percent of the region's total cattle slaughter in
Figure 8. Annual commercial cattle slaughter
Minnesota, 1960 to 1989

Source: U.S. Department of Agriculture, National Agricultural Statistics Service,
Livestock Slaughter, various issues

Figure 9. Commercial slaughter in Minnesota
Share of region's total, by species, 1960 to 1989

Source: U.S. Department of Agriculture, National Agricultural Statistics Service,
Livestock Slaughter, various years
1960 to about 16 percent in 1980. The stable slaughter volume in the state during the 1980s, in contrast to the region's declining volume, has strengthened the relative position of Minnesota plants and by 1989, the state accounted for almost 21 percent of the region's total (Figure 9). Minnesota has seen a greater percentage decline in the number of FI cattle slaughtering plants than has the region or the nation: 40 percent between 1975 and 1989. The trend in the average volume in FI plants in the state has followed closely that occurring in the country as a whole, although the state's average was slightly lower in most years. In 1989, FI plants in Minnesota slaughtered an average of about 23,700 head.

b. Hogs

Nationally, commercial hog slaughter volume has fluctuated sharply since 1960, but the net increase was a relatively modest 12.3 percent, rising from 79 million head in 1960 to 88.7 million head in 1989. Federally inspected slaughter has increased almost 33 percent nationally since 1975 and the average annual plant volume increased by 42 percent between 1975 to 1989, from 54,600 head to 77,500 head.

The Upper North Central region leads the nation in hog production and holds a strong and strengthening position in hog slaughtering. Over the past thirty years, the region's commercial hog slaughter has increased almost 37 percent, a considerably larger increase than in the United States as a whole. In 1960, the region accounted for 32.2 percent of the nation's hog slaughter; by 1989 the share had risen to 39.4 percent. The average annual volume for regional FI plants has been consistently higher than the national average and the increase of 125 percent since 1975 is considerably greater. The region's strong position is due largely to plants in Iowa (Figure 10). Iowa's hog slaughtering industry is in a phase of rapidly increasing plant sizes as facilities continue to seek size economies. The slaughter volume in a "representative" FI Iowa hog plant increased from an average of 581,600 head in 1975 to
Figure 10. Average annual hog slaughter per plant
Federally inspected plants, 1975 to 1989

Source: U.S. Department of Agriculture, National Agricultural Statistical Service,
Livestock Slaughter, various issues

Figure 11. Annual commercial hog slaughter
Minnesota, 1960 to 1989

Source: U.S. Department of Agriculture, National Agricultural Statistics Service,
Livestock Slaughter, various issues
1.2 million head in 1989, a 109 percent increase in fourteen years.

Annual commercial hog slaughter in Minnesota has been relatively stable throughout the 1960 to 1989 period, ranging from a low of 4.4 million head in 1975 to a high of 6.2 million head in 1968 (Figure 11). In the face of a strengthening regional position, however, Minnesota's share is declining, from 22.3 percent of the region's hog slaughter in 1960 to under 15 percent by 1989 (Figure 9). This share will likely prove to have decreased further, as the Albert Lea plant in southern Minnesota was closed for eight and a half months in 1990, and a new plant opened in Waterloo, Iowa in May, 1990, increasing that state's share of the region's total slaughter.

As Figure 10 shows, Minnesota's FI plants are considerably smaller than those in Iowa, but they are larger than the U.S. average and the increase between 1975 and 1989 was greater. In 1975, Minnesota plants slaughtered an average of 78,100 hogs per year; by 1989 the average was 131,800 head, 69 percent higher. The general trend in FI plant numbers in Minnesota is similar to that in the region and the nation, but the 30 percent drop in the state's numbers is smaller than that in the region and greater than in the nation.

c. Sheep and Lambs

As the consumption of lamb and mutton has declined in this country, so has the volume of sheep slaughtered. Commercial sheep and lamb slaughter reached a peak in 1961, but had declined by more than 70 percent by 1979. Since then, sheep and lamb slaughtering has levelled off. The national annual average volume in FI plants has dropped from 9,600 head in 1975 to about 6,000 head in the 1980s.

The Upper North Central region actually lost ground to other regions in total commercial sheep and lamb slaughter from 1960 to 1975. During the early to mid-1980s, the region experienced a small boom in sheep and lamb slaughtering due to plants opening in Iowa. In 1984 and 1985 the region accounted for over 25
percent of the nation's commercial slaughter, but the share has since dropped, reaching 17.5 percent in 1989. The region's share of FI sheep and lamb slaughter has increased since the 1970s, but as a single plant often slaughters the bulk of the region's sheep and lambs, confidentiality rules prevent disclosure of state and regional slaughtering data.

Minnesota leads the region in sheep and lamb slaughtering, typically accounting for 30 percent to 40 percent of the region's total between 1960 and 1989 (Figure 9). Almost 336,000 sheep and lambs were slaughtered annually in the state at the end of the 1980s, up from the levels of the mid-1970s when a typical annual slaughter volume was about 230,000 head, but down considerably from the early 1960s, when volumes often exceeded one million. Minnesota has not reported any FI sheep and lamb slaughtering plants since 1976 and confidentiality requirements prevent detailed examination of the state's plant numbers and slaughter volumes.

d. Calves

Calf slaughter in the United States has followed a trend similar to that of sheep and lamb slaughter: downward. Most of the decline occurred during the 1960s; in the late 1970s there was a brief resurgence, but it was short lived and calf slaughter volumes have continued a gradual decline since then. The downward trend is likely to continue, as consumers' concerns about veal raising practices contribute to reduced veal consumption and also as significantly higher calf slaughter weights in the 1990s mean that fewer calves are now required to produce the same amount of veal. Calf slaughter is typically performed at small plants. Nationally, the average size of a FI calf slaughtering plant has declined from about 5,000 head in the mid- to late 1970s to fewer than 4,000 head in the late 1980s.

Minnesota and the Upper North Central region have witnessed a similar decline in calf slaughter and the region has actually lost some of its share of the nation's total. Wisconsin, with its large dairy industry, has been the only major contributor to
the region's calf slaughter in the 1980s and it accounted for approximately 15 percent of the total U.S. FI calf slaughter in 1989. The average slaughter volume in FI plants in Wisconsin in that year was 35,200 calves. Minnesota's share of the region's total calf slaughter dropped precipitously in the late 1960s, but the state has held a steady, albeit a small, share since then (Figure 9).

2. Concentration of Slaughtering Activities
The livestock slaughtering industry is characterized by having significant economies of size, a characteristic that has contributed to increasing concentration in the industry. For all species, the trend has been toward fewer plants, with large plants accounting for a relatively larger and increasing share of the total slaughter. Typically, mid-sized and smaller plants have either expanded to become large plants, or have gone out of business. One exception to this trend has been among the smallest cattle plants--those slaughtering 10,000 head or fewer annually--, which experienced the smallest relative decrease in numbers over the 1980s.

Plant ownership has also been consolidated over the past decade and a half, more rapidly and to a greater extent in beef than in hog slaughtering. By the late 1980s, the four largest firms slaughtering cattle accounted for between 60 percent and almost 80 percent, with the degree of concentration varying somewhat by the type of plant, and even so, the top three firms are very large and the others are small by comparison.

Concentration in hog slaughtering was estimated to exceed 40 percent by the end of 1990 (Plain, 1990). The firms involved in hog slaughtering continues to change. In 1990, three of the four largest hog slaughtering firms, IBP, Monfort and Excel, were also the three largest cattle slaughterers, yet in 1982 none of these three firms were slaughtering hogs.
B. Vertical Integration

Concern is often expressed, by producers and policy makers, about vertical integration in the agricultural sector. Packer feeding of cattle, and to a lesser degree hogs, is one form of vertical integration. By owning the livestock, packers can more carefully control the flow of animals through their facility, increasing efficiency and reducing processing costs. In the United States in general, packer feeding tends to increase during times of tight livestock supplies. For the period from 1960 to 1987, packer feeding of cattle represented approximately 8 percent of the total U.S. fed cattle marketings. In recent years, forward contracting for delivery and formula pricing have replaced a portion of packer feeding as a means to monitor and control the flow of animals through plants. The Upper North Central states have a smaller proportion of packer feeding than does the nation and Minnesota typically has only a very small percentage of packer feeding; 1.1 percent of all cattle fed in 1987 was the highest level in the state since 1966. Packer feeding and custom contract feeding of hogs has, historically, been less common than for cattle, due largely to differences in production practices. In recent years, however, the incidence of packer feeding of hogs has increased, causing some concern among smaller hog producers.

C. Carcass Grade and Weight Marketing

The share of all species of animals sold for slaughter on a carcass grade and weight (CGW) basis has increased in the United States over the past twenty years, although the patterns of increase have differed among species. By 1987, 30 percent or

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5. There are very few data on packer feeding on an individual state or regional basis, but some national data are collected. The subject is discussed in greater detail in the publication by John Lawrence and Even Bjornstad, from which this section is drawn.
more of cattle, sheep and lambs and calves and 13.5 percent of hogs were sold on a CGW basis.

Minnesota producers sell relatively more of their livestock on a CGW basis than do producers nationwide. Minnesota and Iowa both have significantly higher proportions of CGW cattle sales than does the United States and, in general, a higher percentage of upper-Midwest cattle sales are on a CGW basis than is the case for sales from High Plains feedlots.

Carcass grade and weight sales of hogs in the region increased through the 1970s, but peaked and have been gradually decreasing during the 1980s. One explanation for the decline is the buying practices of one of the leading packers, IBP, which rewards producers for high quality hogs sold on a live weight basis. Although the percentage of CGW hog sales in Iowa have dropped below that for the United States as a whole, Minnesota continues generally to have a larger share of hog sales on a CGW basis than does the nation.

D. Marketing Channels

There are three general types of market through which packers purchase animals for slaughter: auction markets; terminal stockyards; and nonpublic direct markets. Auctions and terminal markets are central locations where buyers and sellers, or their representatives, come together to make and accept bids on animals on site. Direct trade is a transaction between producers and packers or their representatives, such as dealers, order buyers or packer buying stations, that does not require the animals to be moved to an intermediate point prior to the sale.

1. Number of Market Outlets

Livestock auction markets started in the midwest in the first part of the twentieth century. Auction selling of animals reached a peak in 1962, with 2,222 operating markets. The number has declined since then and stood at 1,564 in 1986. The number
of terminal markets has been decreasing steadily since the 1920s and 1930s, when there were approximately eighty terminal markets, and by 1986, only twenty-one such markets remained in operation nationwide. The decline in the number of terminal markets and the volume traded therein is directly related to the movement of slaughtering away from cities, and the terminal markets, to modern facilities near the production areas.

As for the nation, the number of auction markets in the Upper North Central region as a whole decreased, from 266 in 1981 to 239 in 1986, although not all the states in the region adhered to the trend. The number of auction markets in South Dakota has been quite stable at around fifty markets in the 1980s and in Wisconsin the number of auction markets increased slightly, from twenty-eight in 1981 to thirty-three in 1986. Each of the five states had at least one terminal market from 1981 until 1986, and Iowa had two until 1985. The number of local dealers and order buyers is also declining in general, although it fluctuates from year to year. Minnesota saw a considerably larger percentage drop (30.3 percent) in the number of order buyers and dealers between 1981 and 1986 than did either the region or the nation (7.4 percent and 9.8 percent respectively).

2. Volume of Sales Through Each Market Type
Nationally, regionally and in Minnesota, direct marketing is becoming the dominant sales channel for all species, at the expense of public terminal market sales. The trend for auction markets is less marked, but for the most part they seem to be holding their own and in some instances have increased their share of total marketings.

An important exception to the general trend toward greater use of direct marketing is for cattle in the Upper North Central States. Direct marketing in the region did not increase in the 1968 to 1987 period. In the early 1970s, approximately 70 percent of slaughter cattle sales were direct from feeder to packer. The share stayed relatively constant through the 1970s,
but started to decline slightly in the 1980s, falling to 61 percent of all regional cattle sales in 1987. At least part of the decline may be due to a declining number of plants slaughtering fed cattle in the region, leaving farmers no option but to sell through terminal or auction markets. Auction marketing seemed to gain a foothold in the region, increasing its share of total sales from 7.6 percent in 1968 to 23.6 percent in 1987. Cattle sales through terminal markets decreased from 1968 to 1972, but less dramatically than at the national level and has been relatively stable, between 15 percent and 20 percent of the total, since 1972. The number of fed cattle in the region also declined during the period. Typically, fed cattle are sold directly while nonfed cattle (cull cows and bulls) are traded at auction and terminal markets. Thus, changing production patterns went hand-in-hand with the shift away from direct cattle marketing in the region.

Calf, and sheep and lamb marketings in the Upper North Central region and in Minnesota also have not quite followed the general trend, although the difference is less pronounced than for the region's cattle markets. For sheep and lamb marketings, in both the region and Minnesota, direct marketing has been the dominant marketing channel since 1968, with between 60 percent and 80 percent of the total. Marketings through auctions and terminal markets vary and no trend is discernable. Direct calf sales in the region as a whole decreased between 1968 and 1974, then increased, and while terminal market sales decreased, they still command a larger share of the region's calf sales than of the nation's. In Minnesota almost all calf sales since the 1960s have been through direct marketing channels.

E. Regional Processing as a Share of Production

One key to the long term success of a state or region's livestock industries is the attainment of some degree of equilibrium between production and processing capacity. Livestock producers
near a slaughtering facility receive a higher net selling price, due to lower transportation costs and less condition loss than do producers far removed from the plant. Similarly, plants with a ready supply of animals nearby have lower overall procurement costs than do plants that must draw their animals from a large geographic area. Also important for individual states is the location of larger commercial slaughtering plants. States with such plants receive tax revenue and employment benefits from the plant as well as offering local producers a ready market for their animals. States that do not have large plants within their borders need to look at whether there are alternative viable markets in neighboring states, if their livestock industries are to remain healthy.

Although data describing the relationship between livestock production and processing facilities over a long period are unavailable, there are data for the period between 1983 and 1987. As Table 1 indicates, with the exception of Minnesota's sheep industry, production in the Upper North Central region and in Minnesota exceeded commercial slaughtering capacity in 1987, requiring some animals to be shipped out of the region for slaughter.

1. Cattle
The region's farmers produce more cattle than its plants slaughter; between 1983 and 1987, 70 percent to 80 percent of the total production was killed in regional plants. Plants in the states bordering the region, such as Nebraska and Illinois, were most probably the recipients of the excess cattle.

Although there were several smaller cull cow and bull slaughtering facilities operating in the region, the location of steer and heifer slaughtering plants is more crucial to the future of the region's beef subsector. Of particular interest are plants with an annual capacity of 100,000 head or more. The region has a total of ten such packers, two in each Minnesota and Wisconsin, one in South Dakota, and five in Iowa. There are
seven such plants in Nebraska and two in Illinois that are within fifty miles of the regional boundary. While there are a few areas within the region that are a great distance from one, or particularly two or more, packers, the region as a whole is fairly well endowed with large packers as the country had only a total of sixty-six plants slaughtering 100,000 head or more in 1989.

Minnesota's cattle industry seems to be losing slaughter capacity relative to production. Approximately 64 percent of the state's production was slaughtered in Minnesota in 1987 (Table 1), compared to 76 percent in 1983. Access to packers varies within the state. Southwest Minnesota has two steer and heifer plants and is relatively close to plants in South Dakota and northwest Iowa. The remainder of the state is further from packers, as Wisconsin's plants are located on the eastern side of the state, and thus producers in northern and eastern Minnesota are disadvantaged by high transportation costs, even though their on-farm costs may be comparable to those in the southwestern part of the state.

2. Hogs
The percentage of the region's hogs that are slaughtered within the region is higher than for cattle and generally exceeds 90 percent. Iowa is a hog deficit state, slaughtering more than it produces, but the rest of the states produce more hogs than they slaughter.

As is the case for cattle, the region has a relatively large number of commercial hog packers. Although the numbers change with plant openings and closing, the region had approximately half of the nation's hog slaughtering plants with an annual capacity of one million hogs or more. Iowa had twelve of the seventeen plants open or scheduled to open as of late 1990. Minnesota had three and South Dakota two plants, and there are also plants nearby in Nebraska and Illinois.
Minnesota's hog processors have been absorbing between 80 percent and 90 percent of the state's hog production, except for a low of 65.3 percent in 1985. The three packers are located in the state's southern tier of counties, as is the bulk of the state's hog production. Southern Minnesota producers are also served by packers in southeastern South Dakota and northern Iowa. Hog producers in southern Minnesota therefore have an advantage over their north-state counterparts, due to their proximity to processing facilities.

### Table 1. Slaughtering as a share of production, Upper North Central region and Minnesota, 1987

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<thead>
<tr>
<th></th>
<th>Upper North Central region</th>
<th>Minnesota</th>
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<tr>
<td>Cattle</td>
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<td>64%</td>
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<tr>
<td>Hogs</td>
<td>90%</td>
<td>80 - 90%</td>
</tr>
<tr>
<td>Sheep and lambs</td>
<td>80%</td>
<td>224%</td>
</tr>
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</table>

### 3. Sheep, Lambs and Calves

The region was a net importer of sheep and lambs for slaughter between 1983 and 1986, but in 1987 only 80 percent of the region's production was slaughtered here. Such a wide swing is usually associated with a single plant closing rather than abrupt changes in production. Minnesota slaughtered almost 60 percent more than its production in 1983 and by 1987 Minnesota plants slaughtered more than twice the state's production (Table 1).

It is almost impossible to gauge the proportion of calves produced that are slaughtered within the region or state as many calves are not slaughtered for veal, but fed out to mature weight and slaughtered as steers or heifers or are kept as replacement heifers.
IV. FARM LEVEL TRENDS IN MINNESOTA'S LIVESTOCK INDUSTRIES

The livestock industry in Minnesota has changed considerably in the past several decades. The changes have generally been toward fewer farms with more animals and higher production per animal. Of particular interest for this report are trends in the number of farms with livestock, in the number of animals (total and per farm), and in production efficiency, for cattle, hogs, sheep and poultry farms. The trends in economic efficiency for farms in Minnesota and in the Upper North Central states are compared to those in other regions of the United States to get a picture of the competitiveness of the Minnesota and regional livestock industries. Similar comparisons are made for farms of different sizes. Simple trend extrapolations are used to project farm and livestock numbers and production in the year 2000.

A. Farm Size and Number of Farms

Early records show that Minnesota had 157 farms in 1850 and 18,181 just ten years later. Over the next eighty-five years, the number of farms continued to rise rapidly, reaching an historical high in 1935, at 204,000 farms. Since then the trend in farm numbers has been downward, dropping back to 89,000 in 1990. According to the U.S. Census of Agriculture, the number of farms in the country was 2.1 million in 1987, down from 6.4 million in 1910 and 1920 (Stanton, forthcoming). The rate of decline appears to have been fairly steady since the 1950s, except after the mid-1970s, when a change in the definition of a "farm" resulted in a sudden drop in U.S. farm numbers.

6. The material in this section is drawn extensively from Kent D. Olson, Even Bjornstad, and Jorunn Grande, Changes in Minnesota's Livestock Industry: Farm Level Trends, Staff Paper P92-9, University of Minnesota, Department of Agricultural and Applied Economics, April, 1992.
Although the number of farms in Minnesota has dropped by more than half over the last five decades, the amount of land in farms has not changed drastically (Figure 12). More than 90 percent of all land classified as farmland in Minnesota is still farmed. In 1935, 32.9 million acres were farmed in the state; in 1990, 30 million acres were farmed. The average size of Minnesota's farms has increased considerably, from 165 acres in 1940, to 326 acres in 1987. For the United States as a whole, the corresponding farm sizes were 174 acres and 462 acres in 1940 and 1987 respectively.

B. Livestock Numbers

1. Dairy Cattle

The number of dairy farms and the number of milk cows in the state have decreased since the 1940s (Figure 13), although total milk production has increased. According to the Minnesota Agricultural Statistics Service, the number of farms with dairy cows declined from 179,000 in 1941 to 15,500 in 1990. The total number of milk cows in the state has followed a similar trend. It peaked in 1943, at 1.7 million head, then began dropping and by 1990 there were 710,000 milk cows in the state.

The rate of decline in farm numbers has shown little indication of slowing in recent decades. Between 1970 and 1980, the number of dairy farms declined by 41 percent, an average loss of 1,900 farms per year. In the following decade, a period of severe financial stress for farming in the country as a whole, the number of dairy farms in Minnesota declined by 43 percent, or an average annual loss of 1,150 farms. The downward trend thus appears to be continuing apace, regardless of the economic conditions in the sector.

2. Beef Cattle

The number of beef cows in Minnesota increased from 91,000 in 1939 to a peak of 751,000 in 1976, before the trend reversed
Figure 12. Number of farms and land in farms
Minnesota, 1930 to 1990

Source: Minnesota Agricultural Statistics and U.S. Census of Agriculture, various years

Figure 13. Farms with dairy cows, Minnesota
Number of farms and number of cows, 1930 to 1990

Sources: Minnesota Agricultural Statistics and U.S. Census of Agriculture, various years
By 1991 the total beef cow herd had decreased by about one half, to 375,000 head. The number of farms with beef cows also dropped, from 28,170 in 1964 to 15,528 in 1987. The number of cattle fed for beef followed a roughly similar trend, increasing from 321,000 in 1955 to 589,000 in 1970. Since then, Minnesota's fed cattle inventory has fluctuated. A declining trend can be seen from 1970 to the mid-1980s, but it may have stabilized again in recent years (Figure 15). As of the beginning of 1990, there were 345,000 head of cattle on feed in Minnesota.

3. Hogs
Minnesota's hog industry has undergone a substantial change since the 1960s. In 1950, 62 percent of the state's farms, more than 100,000 farms, had hogs. Since then, as Figure 16 shows, hogs have disappeared from the majority of farms and the number of farms with hogs has declined almost without interruption. In 1990 there were 15,000 hog farms in Minnesota, 17 percent of all farms.

The sharp decline in the number of hog farms is not reflected on the output side. The number of sows producing a litter of piglets has fluctuated at times (especially around 1940 and in the late 1970s), but the average since 1930 has usually been between 0.8 million and 1 million. The pig crop fluctuated around an annual average of 6 million pigs until 1979, when it increased to almost 8 million pigs. In 1990, the pig crop was 7.9 million pigs. Average annual production per farm increased from 94 pigs in 1965 to 524 in 1990.

4. Sheep
The trends for sheep farms in Minnesota are similar to those for other species (Figure 17). The sheep breeding herd increased to a peak in 1942 and 1943, of 1.2 million head. By the end of the 1940s, however, the number had decreased almost by half. The numbers increased slightly and then stabilized in the 1950s,
Figure 14. Farms with beef cows, Minnesota
Number of farms and number of cows, 1930 to 1990

Sources: Minnesota Agricultural Statistics and U.S. Census of Agriculture, various years

Figure 15. Number of cattle on feed, Minnesota, 1955 to 1991

Source: Minnesota Agricultural Statistics, various years
Figure 16. Farms with hogs, Minnesota
Number of farms and sows farrowed, 1930 to 1990

No. of farms (1,000) Sows farrowed (1,000)

Year

Source: Minnesota Agricultural Statistics and U.S. Census of Agriculture, various years

Figure 17. Farms with sheep, Minnesota
Number of farms and stock sheep, 1930 to 1991

No. of farms (1000) No. of stock sheep (1000)

Year

Source: Minnesota Agricultural Statistics and U.S. Census of Agriculture, various years
before beginning another sharp decline in 1962. The number of stock sheep reached a low of 150,000 head in 1986, but had increased again, slightly, to 210,000 head by 1990. The number of sheep farms reached a high of 37,000 in 1935. It then declined and, although it increased slightly in the 1950s, by 1987 had declined to 4,250 farms.

Patterns in the number of lambs saved and marketed in Minnesota are similar and follow the trend in the number of farms. In most years the number of sheep marketed in the state has been higher than the number of lambs saved, because sheep are imported from other states. The number of lambs saved per stock sheep has increased, slowly but steadily, from 0.8 in 1930 to 1.0 in 1990.

5. Poultry
a. Eggs
Minnesota's egg production has contracted considerably since the mid-1930s, as the number of farms has fallen from 169,000 in 1935 to only 4,000 in 1987. The drop in the total number of eggs produced, however, has been less dramatic. The number of layers on farms peaked in 1944, at 27 million, then fell steadily until 1970 (Figure 18). The number has fluctuated since then, between 10.7 million in the early to mid-1970s and 9.6 million in 1990.
b. Broilers and Turkeys
At the same time that the state's egg industry was contracting, production of broilers and turkeys was expanding. Although the number of farms selling broilers reported by the U.S. Census of Agriculture dropped from 3,011 in 1974 to 1,589 in 1987, the total number of broilers has increased, almost without pause, since the late 1950s. According to the Minnesota Agricultural Statistics Service, there were 2.5 million broilers on Minnesota farms in 1955 and the number had increased to over 41 million in 1990 (Figure 19). The average number of broilers per farm was about 3,600 in 1974, but by 1987 it had increased more than five-fold, to 19,950 birds per farm.
Turkey production has also increased rapidly in Minnesota. In 1930, 1.3 million turkeys were raised in the state; in 1990 the number was 46.3 million (Figure 19). The number of farms producing turkeys dropped from 4,868 in 1945 to 370 in 1974, then increased again to 723 farms in 1987. The average number of turkeys per farm has increased from about 820 in 1945 to 56,000 in 1987.

C. Measures of Productivity

There are various ways of measuring productivity and changes therein. One way is to look at technical productivity, or production per animal unit. Another is to look at costs and returns, which takes into account expenses incurred in producing the total output and prices received for the product. The general trend in production per animal in the United States and in Minnesota has been upward over the past fifty years or more. Data for several of the state's livestock industries show this trend clearly. Milk production per cow increased almost threefold between 1930 and 1990, to an average of 14,093 pounds per cow. Productivity in hogs may be measured by the number of piglets per litter. Since 1930, there has been a steady, although not dramatic, rise in average litter size, from 5.9 piglets in 1930 to 8.1 in 1990. The pattern for sheep is similar; between 1930 and 1990, the number of lambs saved per stock sheep rose from 0.8 to 1.0. Hen productivity, in terms of the average number of eggs produced per year, has risen substantially, from 118 per year in 1930 to 259 eggs per year in 1990. These gains in productivity are due to a combination of improved genetics, improved health and nutrition, and improved management techniques.

While some of the technical gains are quite impressive, ultimately we are interested in the bottom line: What is the net return, after all the costs are covered? This residual amount is
Figure 18. Farms with layers, Minnesota
Number of farms and number of layers, 1930 to 1990

Source: Minnesota Agricultural Statistics and U.S. Census of Agriculture, various years

Figure 19. Broiler and turkey production, Minnesota
1930 to 1990

Source: Minnesota Agricultural Statistics, various years
subject to variation, with the volatility varying among enterprises. The two main sources of variation are output prices and production costs. By using two different concepts, total economic cost and residual returns to management and risk, we can sort out the different sources of variation in a producer's returns. Total economic cost is a measure of all production costs: fixed and variable cash expenses and the opportunity cost of owned inputs, including unpaid labor. Residual returns to management and risk is a measure of what remains from the sale of one unit of product, after the total economic cost of producing it is subtracted. By comparing these measures among geographic regions and across farm size categories, we can see how the Upper North Central region fares in terms of competitive position for various production activities and how competitive are farms of different sizes. These costs have been estimated by the U.S. Department of Agriculture, using consistent procedures for all farm sizes and all geographic regions (USDA).

1. Dairy
The competitive position of Minnesota, and of the Upper Midwest in general, in milk production has slipped relative to other regions of the country since 1985, as costs here have increased more rapidly here than they have elsewhere (Figure 20). While the Pacific states have the lowest costs of production per hundredweight of milk, Appalachia has the highest residual returns per cow. Residual returns per hundredweight of milk have been declining in all regions since 1987 and in 1988 they were lowest in the Upper Midwest.

2. Beef Cattle
Total economic costs for cow/calf operations of all sizes have been generally increasing over the past two decades. These costs are higher for smaller operations than for large ones and the difference appears to be widening in recent years (Figure 21). Regionally, farms in the West and the Great Plains have, on
average, significantly lower costs per cow than do farms in the North Central and southern states. Average residual returns have, however, been negative for all farm sizes in all regions, except in 1979, when larger farms and farms in the West showed a small positive return. The existence of persistent losses for cow/calf operations raises the question of how the operators manage to stay in business. One plausible explanation is that these farmers and ranchers are accepting lower wages and returns on their investment than was used in calculating average residual returns. Perhaps they consider the nonmonetary benefits of cattle raising to be worth more to them than a higher wage. And presumably their cash flow has been positive in enough years to allow these farmers to continue to enjoy their chosen lifestyle.

Total economic costs for cattle on feed have been relatively stable over fairly long periods, hovering around $45 per hundredweight for both commercial and farmer feedlots through most of the 1970s then rising steeply between 1978 and 1980 to about $65 per hundredweight. The difference in costs for commercial and farmer feedlots began to widen in the 1980s, with costs for commercial lots actually dropping slightly in the first half of the decade. By the mid-1980s, costs for both size categories had started to rise again, but the gap between farmer and commercial operations remains.

Residual returns to management and risk show considerable year-to-year variation for operations of all sizes. The story is similar to that for costs; farmer feedlots have seen returns gradually become more negative, while returns for commercial lots averaged around zero in the early 1980s and rose somewhat mid-decade.

3. Hogs
Estimates of total economic costs show that smaller farrow-to-finish hog operations have higher production costs than do larger
Figure 20. Total economic cost, milk production
All farm sizes, by region, 1985 to 1988

$ per cwt

1986 1987 1988

Source: U.S. Department of Agriculture, 1990

Figure 21. Total economic cost, beef cow/calf operations
U.S. average, by herd size, 1972 to 1988

$ per cow


Source: U.S. Department of Agriculture, 1990
Interestingly, the total economic costs per hundredweight appear to be very similar over a range of mid-sized operations. As Figure 22 illustrates, farms with 650 head had almost the same production costs as did farms with 1,600 head during the 1980s. Returns to management and risk were consistently higher for larger hog farms from 1972 to 1988.

Regional cost differences have also been apparent. Total economic costs per hundredweight for farrow-to-finish hog operations have been lower in the North Central region than for farms in the other major hog producing region, the Southeast. During the 1980s, the North Central region had lower costs for finishing feeder pigs than did the Southeast, which was a reversal of the regional positions of the 1970s (Figure 23). Residual returns have mirrored this pattern, with the North Central region having had higher returns than the Southeast in the 1980s. Costs for producing feeder pigs have fluctuated, but have been consistently higher in the Southeast than in the North Central region since the early 1970s. Average residual returns to management and risk for feeder pig production, which have shown greater variation than have costs, have been negative in both the North Central and the Southeast since the late 1970s.

D. Projections
For most of this century, the U.S. agricultural sector has experienced a consolidation, characterized by a steady decline in farm numbers and the portion of the population involved in farming, and an increase in average farm size. The process is simply one of natural economic evolution. As nonfarm jobs have

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7. Farrow-to-finish operations grow pigs from birth to slaughter weight. Finishing operations take pigs at about 40 pounds and grow them out to finish, or slaughter, weight. Most hog operations currently are farrow-to-finish, but some farms do specialize in finishing feeder pigs and some farrow-to-finish operations purchase feeder pigs and, thus, finish more pigs than they farrow on the farm.
Figure 22. Total economic cost, farrow-to-finish operations
U.S. average, by herd size, 1980 to 1988

$ per hundredweight

Source: U.S. Department of Agriculture, 1990

Figure 23. Total economic cost, feeder pig finishing,
All farm sizes, North Central and Southeast,
1972 to 1988

$ per hundredweight

Source: U.S. Department of Agriculture, 1990a
become more available and more attractive, so the farm labor force has diminished. A wide spectrum of technological developments have allowed those who remained in farming to use their labor more efficiently. Changing markets, changing demand patterns, and changing infrastructure support systems have influenced interregional competitiveness, so that production and processing loci have shifted gradually to adapt to changing economic environments. Minnesota's livestock industries have clearly been affected by these forces and will continue to be in the future.

Although making projections puts one somewhat into the role of a seer, estimates or forecasts of conditions in the future are crucial for planners, policy and decision makers, managers and investors, and of great interest to almost all participants in an industry. For fairly short term projections, those from one to ten years into the future, it is reasonable to assume, in the absence of strong indications otherwise, that major forces will continue to follow their recent historical trends.

To make projections for Minnesota's livestock industries, we calculated the average annual percentage change in farm and livestock numbers and livestock production over the past five years (or past ten years if the past five have been particularly volatile). We then extrapolated these trends to obtain simple, understandable projections of numbers and production levels in the year 2000. These trend extrapolations were checked and adjusted, if needed, to assure that the final forecast was consistent with trends and interactions in underlying forces, such as farm numbers, numbers of animals, productivity per animal and Minnesota's share of production. The projections are presented as rounded numbers to show trends rather than to pinpoint exact future numbers. Also, the trends and averages

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apply to each of the industries as a whole. Within each industry there will certainly be individuals who, due to their particular situation, management style, ingenuity or business acumen, will buck a declining trend and prosper. It is also possible that some of the trends we have identified will not continue along their current paths. In Section V we discuss some events and forces that could change the trends underlying our basic assumption.

1. Number of Farms
The total number of farms in Minnesota is projected to decline from 89,000 in 1990 to 77,000 in 2000 (Table 2). As the total farmland declines at a slower rate, the average farm size is projected to increase from 337 acres to 382 acres by the year 2000.

Table 2. Number of farms in Minnesota, 1970, 1980, 1990 and projections for 2000

<table>
<thead>
<tr>
<th></th>
<th>1970</th>
<th>Actual</th>
<th>1990</th>
<th>Projection</th>
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<tbody>
<tr>
<td></td>
<td></td>
<td>1980</td>
<td></td>
<td>2000</td>
</tr>
<tr>
<td>Total no. of farms</td>
<td>121</td>
<td>104</td>
<td>89</td>
<td>77</td>
</tr>
<tr>
<td>(thousand)</td>
<td></td>
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<tr>
<td>Total farmland</td>
<td>30.9</td>
<td>30.3</td>
<td>30</td>
<td>29</td>
</tr>
<tr>
<td>(million acres)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average farm size</td>
<td>255</td>
<td>291</td>
<td>337</td>
<td>382</td>
</tr>
<tr>
<td>(acres)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of farms with:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dairy</td>
<td>46</td>
<td>27</td>
<td>15.5</td>
<td>8</td>
</tr>
<tr>
<td>(thousand)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Beef cow/calf</td>
<td>Not avail.</td>
<td>Not avail.</td>
<td>15</td>
<td>10</td>
</tr>
<tr>
<td>Hogs</td>
<td>42</td>
<td>35</td>
<td>15</td>
<td>9</td>
</tr>
<tr>
<td>Sheep</td>
<td>11</td>
<td>8</td>
<td>5.2</td>
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</tr>
</tbody>
</table>

Source: Minnesota Agricultural Statistics, various years, for actual numbers. Projections based on procedures described in this paper.
The number of farms with livestock is projected to decline at a faster rate than does the total number of farms, resulting in an agricultural sector in the state with relatively more cash crop farms and fewer diversified crop-livestock farms than at present. The greatest projected decrease is in dairy farms, from 15,500 farms in 1990 to 8,000 farms in 2000. The projected decline for beef cow/calf farms is from 15,000 to 10,000 and for hog farms from 15,000 to 9,000, between 1990 and 2000.

2. Cattle

The projections subject to the greatest uncertainty are those for dairy farms, because of the interactions among several important variables. These variables include Minnesota's share of national milk production, per cow productivity and the adoption of on-farm technology, which can affect the number of cows per farm. Simply extrapolating current trends yields conflicting results in terms of number of cows, number of dairy farms, and cows per farm.

In our projection we estimated future milk production for the entire state, assuming the trends of the 1980s continue. Total production is projected to decrease to 8,530 million pounds in 2000. With annual milk production per cow continuing to rise at the current rate, reaching an average of about 18,500 pounds by the year 2000 (Table 4), the state's production will be met by a total of 460,000 cows (Table 3). The trend in the number of cows per farm points to an average of sixty cows per herd in 2000. Thus, fewer than 8,000 farms would be needed under this scenario.

There are, however, alternative projections that should also be considered. If Minnesota's total milk production were to remain at 10,000 million pounds, then 540,000 cows would be needed on 9,000 farms, with an average herd size of sixty cows. If, as some observers predict, a larger proportion of future retirements of dairy farmers are those with smaller herds (without replacement), the average herd size may rise above
sixty. In addition, technology adoption may have the effect of pushing herd size up. The net effect would be that fewer, larger herds would provide the state's total milk production. If milk production per cow does not maintain its current rate of increase, Minnesota's dairy farms will be less competitive compared to those in other regions and the state will lose dairy farms.

The beef cow herd is also projected to shrink, to 260,000 head in 2000 (Table 3). This inventory reduction will likely be slower than the decrease in the number of farms, so the average beef herd size will also increase, from 23 cows in 1990 to 26 cows in 2000.

Beef feeding is projected to continue to decline in the state, but over the past decade the magnitude and direction of the changes have varied, suggesting that it has not yet stabilized onto a clearly downward trend.

3. Hogs
Minnesota's hog industry is projected to grow, even though the number of hog farms will likely decrease. As Table 3 indicates, the number of sows producing a litter of piglets is projected to increase from 965,000 in 1990 to 1,050,000 in 2000, and average farm size is projected to rise from 64 sows farrowing in 1990 to 130 in 2000. Total piglets per litter is also projected to increase, to 8.6 in 2000 (Table 4). The total pig crop could be as high as 9 million pigs by the end of the century (Table 3). These increases are projected even though the data from 1980 to 1990 (as shown in Table 3) suggest a downward trend. The projections are based on an extension of the long term trend that began in the 1960s and the upturn in the industry in the late 1980s (Figure 16).

4. Sheep
Minnesota's sheep industry is expected to continue to decline, but at a slower pace than in the 1960s and 1970s. Farm numbers

<table>
<thead>
<tr>
<th></th>
<th>1970</th>
<th>1980</th>
<th>1990</th>
<th>Projection</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total no. of head</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(thousand)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All cattle (Jan. 1 inventory)</td>
<td>3958</td>
<td>3750</td>
<td>2600</td>
<td>1400</td>
</tr>
<tr>
<td>Milk cows (ann. av.)</td>
<td>949</td>
<td>860</td>
<td>710</td>
<td>460</td>
</tr>
<tr>
<td>Beef on feed (Jan. 1 inventory)</td>
<td>589</td>
<td>390</td>
<td>300</td>
<td>200</td>
</tr>
<tr>
<td>Beef cows (Jan. 1 inventory)</td>
<td>523</td>
<td>560</td>
<td>350</td>
<td>260</td>
</tr>
<tr>
<td>Calves born (ann. tot.)</td>
<td>1473</td>
<td>1350</td>
<td>1070</td>
<td>710</td>
</tr>
<tr>
<td>Sows farowed (ann. tot.)</td>
<td>823</td>
<td>1195</td>
<td>965</td>
<td>1050</td>
</tr>
<tr>
<td>Pig crop (ann. tot.)</td>
<td>6065</td>
<td>8937</td>
<td>7863</td>
<td>9000</td>
</tr>
<tr>
<td>Stock sheep (Jan. 1 inventory)</td>
<td>423</td>
<td>217</td>
<td>210</td>
<td>100</td>
</tr>
<tr>
<td>Sheep marketed (ann. tot.)</td>
<td>544</td>
<td>194</td>
<td>217</td>
<td>150</td>
</tr>
<tr>
<td>Lambs saved (ann. tot.)</td>
<td>397</td>
<td>205</td>
<td>220</td>
<td>120</td>
</tr>
<tr>
<td>Comm. broilers (mill. raised)</td>
<td>10.95</td>
<td>19.4</td>
<td>41.3</td>
<td>100</td>
</tr>
<tr>
<td>Layers (mill., ann. av.)</td>
<td>9.9</td>
<td>8.8</td>
<td>9.6</td>
<td>9</td>
</tr>
<tr>
<td>Turkeys (mill. raised)</td>
<td>18.3</td>
<td>25.5</td>
<td>46.3</td>
<td>110</td>
</tr>
</tbody>
</table>

Source: Minnesota Agricultural Statistics, various years, for actual numbers. Projections based on procedures described in this paper.


<table>
<thead>
<tr>
<th></th>
<th>1970</th>
<th>1980</th>
<th>1990</th>
<th>Projection</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total milk</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(million pounds, ann. tot.)</td>
<td>9636</td>
<td>9535</td>
<td>10006</td>
<td>8530</td>
</tr>
<tr>
<td>Milk per cow</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(pounds, ann. av.)</td>
<td>10154</td>
<td>11061</td>
<td>14093</td>
<td>18500</td>
</tr>
<tr>
<td>Eggs per hen</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(ann. av.)</td>
<td>234</td>
<td>242</td>
<td>259</td>
<td>290</td>
</tr>
<tr>
<td>Piglets per litter</td>
<td>7.4</td>
<td>7.5</td>
<td>8.1</td>
<td>8.6</td>
</tr>
<tr>
<td>Lambs saved per stock sheep</td>
<td>0.9</td>
<td>0.9</td>
<td>1.0</td>
<td>1.2</td>
</tr>
</tbody>
</table>

Source: Minnesota Agricultural Statistics, various years, for actual numbers. Projections based on procedures described in this paper.
are projected to decrease (Table 2), as are the numbers of stock sheep, sheep marketed, and total lambs saved (Table 3). The average number of lambs saved per stock sheep, however, is projected to increase from 1.0 in 1990 to 1.2 in 2000 (Table 4).

5. Poultry
Minnesota's poultry industries--broilers, turkeys, and eggs--are all projected to expand by the year 2000. The number of commercial broilers are projected to increase by about 9 percent per year, to 100 million in 2000; the turkey flock is projected to increase to 110 million in 2000 (Table 3). Although the number of layers on farms is projected to fall slightly, from 9.6 million to 9 million, the number of eggs produced per hen per year is projected to increase to 290 per year by 2000 (Table 4), resulting in a net increase in egg production.

V. IMPLICATIONS FOR MINNESOTA'S LIVESTOCK INDUSTRIES OF ALTERNATIVE SCENARIOS

The projections for Minnesota's livestock industries put forth in the preceding section are based on the assumption that past trends in the industries and in the forces driving the changes will continue. There are, however, many forces that could invalidate this assumption. The following forces are particularly important and are discussed in some detail below: the nation's economic health; consumers' tastes and preferences; population shifts among regions within the United States; agricultural policy; the availability of new technology; public concern about, and the possible resulting regulation associated with, natural resource conservation, environmental quality, food

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safety, and animal welfare or animal rights; and international turmoil or disturbances associated with war, political instability, or major food shortages.

A. Economic Growth or Recession
The health of the agricultural sector is inextricably intertwined with the health of the general economy. When the rest of the economy is growing rapidly, opportunities for employment outside the agricultural sector are plentiful and the rate of structural adjustment within the agricultural sector is likely to keep pace with that in the general economy. Specifically, marginal producers can easily find employment outside the agricultural sector, or at least off the farm, as they did in large numbers during the growth periods of the 1950s and 1960s. Thus, if the general economy is growing fast, especially relative to the recent past, the trend toward fewer and larger farms would most likely accelerate, as some farmers leave farming and others buy their land and equipment. This trend would hold for both crop and livestock farms.

In contrast, during recessionary periods, structural change may slow, as conditions in the general economy are reflected in the agricultural sector, or the nature of the structural change may alter. In a recession, aggregate demand declines or growth slows, alternative employment opportunities outside agriculture are less available, and new investment in agriculture may be curtailed. Fewer farmers may quit farming, because opportunities elsewhere are more limited and because there is less interest by others in taking over their farm assets.

Alternatively, rather than simply slowing, the structural change may be of a different nature during a recessionary period. Arrangements among buyers and sellers may change. For example, farmers may seek contractual arrangements for selling their commodities when prices are low, seeing contracts as offering a greater chance for profit. Another response to low prices for
one commodity or group of commodities could be a shift in production. Grain farmers, facing low grain prices may decide it is more profitable to be their own customers for grain and move into livestock production. They may make such a move individually or join with others to build a single, large livestock operation. Efforts such as these, even by one segment of the agricultural sector, can have ripple effects throughout the sector that last well beyond the period of low commodity prices.

The effect on agriculture of general economic conditions is especially evident when the growth or recessionary periods are prolonged. In the 1970s and 1980s, the economy has had relatively short cycles of growth and downturn. If that pattern continues, structural change can be expected to follow quite closely the trends established in those decades and the projections in the previous section will likely hold.

B. Changes in Consumers' Tastes and Preferences

Two trends in consumer behavior could potentially have a significant impact on the structure of livestock industries, nationally and within the Upper North Central region and Minnesota. These two trends, which were discussed earlier, are the changing American diet and the increasing demand for services associated with food products.

Our concern here is to consider what these changing patterns may mean for livestock industries in the future. Some livestock producers, especially those producing products that are, or are perceived to be, high in fat, may well see the demand for their product decline and prices drop. They will be faced with the choice of adapting--changing their product to meet the changed consumer tastes--or, especially those with higher production costs, going out of business. To the extent that the producers with the highest costs of production are the smaller operations, the result will be a livestock industry characterized by fewer,
larger operations. Many small operators may, however, be well placed to change their products to suit specific consumer markets.

The increase in demand for food requiring less (or none) of the consumers' time to prepare imposes a different set of forces for change on livestock producers. As processors, retailers, or restaurants perform more of the food preparation activities, the demand for large quantities of raw product with consistent quality characteristics will increase. A quarter pound of ground beef, for example, should always cook down to a patty the size of a hamburger bun, therefore the proportion of fat cannot vary by much. Processors will increasingly look for producers with whom they can contract to supply consistently, fairly large quantities of raw product that meets certain specifications, thereby reducing the number of transactions and the possibility of quality variation. Again, adaptability may well be the key to gaining the advantage in these new markets, while the size of operation may be relatively less important.

C. Population Shifts

Although the total U.S. population is growing at a fairly slow rate, and thus total demand for livestock products is also growing only slowly, regional patterns of growth differ across the country. Over the past decade, population growth has been greater in the south and the southwest than in the north. Without delving into the additional complexity added by the different age composition in various regions and the effect of the population's age structure on demand for livestock products (discussed in the section on consumption), a rate of population growth in the southern states that is greater than that in the northern states puts producers in the northern states at a relative disadvantage due to transportation costs. This relative disadvantage would be exacerbated if energy costs were to rise at
a greater rate than they have in the recent past, but it might also be muted if energy cost increases were to slow.

D. Changes in the Level of Government Intervention in Agriculture

Government intervention in agricultural markets in the United States is more prevalent in the crop subsectors than it is in most livestock subsectors, with the notable exception of the dairy subsector. The livestock industries are not, however, completely immune from government actions, although the net effect of these actions on the rate of structural change in the livestock subsectors is far from clear. Recognizing that there are a myriad of exceptions to any generalization, especially ones associated with agricultural policy, we believe we can say that, in general, a move away from government intervention and controls on agricultural production, toward a situation of freer markets, will usually allow structural change to occur in response to general economic conditions. In other words, the government programs create a buffer between the general economy and the agricultural sector.

To the extent that there has been considerable discussion about moving toward freer international markets, under the auspices of the General Agreement on Tariffs and Trade (GATT), there may be some impetus for structural change in the agricultural sector to occur more rapidly than it has in the recent past. A move to freer markets is, however, far from certain, and in the event that little or nothing is achieved in agriculture in the current GATT round, protectionism and barriers to agricultural trade could rise, in the United States and in other countries, possibly slowing down the rate of structural change in farming and also reducing access to some markets for U.S. agricultural products.
E. Availability of New Technology

One of the most powerful forces influencing agriculture has been the availability and subsequent adoption of new technology. Most projections that predict continued structural changes in the sector assume that new, cost-reducing technologies will continue to flow steadily into American and world production systems. Technologies now available for livestock industries that will continue to contribute to structural change include genetic improvement, seedstock evaluation, carcass evaluation, and information gathering and dissemination. Important among the technologies that many of the projections assume will be introduced and adopted in agriculture in the near future are those broadly classed as biotechnologies. If the promises of important new advances associated with the applications of biotechnology are realized, increases in productivity and cost reductions per unit of output can be expected to occur, for many commodities around the world. As has been true in the past, most of the economic benefits from new technology will accrue to early adopters. In cases where the adoption of the technology requires a large capital investment, the likely consequence in the United States will be an acceleration of the trend toward fewer, larger and more specialized producing units.

If the productivity advances arising from the new technologies are more elusive, or if the rate of adoption is slower than predicted, the rate of structural change may also slow. Several factors and trends, alone or in combination, could act to alter both the rate and nature of structural change in the agricultural sector due to new technology. Restrictions or limits on the use of chemical pesticides, fertilizers and growth hormones, or a slowing in the rate of release of yield increasing technologies could impinge on agriculture and decrease the competitiveness of farms of all sizes, especially those operated on a part-time basis. Small, family farms with full time operators may become relatively more competitive if the net effect of these trends is to increase the amount of farmer
management time needed per unit of output. If new technologies, such as genetically improved varieties or breeds and seedstock evaluation techniques, are closely held and access to them controlled by contracts or made very expensive, the structural shift in farming may be toward larger operations that are more willing and able to pay the price.

F. Public Concerns

Over the past decade, the public's awareness and concern has heightened, about the impact of agricultural production practices on environmental quality, about personal health and safety (beyond that associated with fat and cholesterol intake) and about animal welfare. The focus of these concerns runs the gamut, from the depletion and degradation of natural resources, especially land and forests, to the presence of various contaminants in food and water supplies, to the housing, treatment and transportation of animals used for food or fiber, or in scientific experiments. How these public sentiments, and efforts to deal with them, might affect farm structure is difficult to assess.

In the current fiscal and policy environment, the most likely approach for addressing these concerns will be via regulation of and restrictions on economic activities. Regulations and restrictions may be imposed at the federal, state or local level, or all three, and the impact on competitiveness will vary with the different levels of control. The broader are the regulations or restrictions, the less they will affect relative regional or state competitive positions, although they may well change the relative competitiveness of the United States in the world market. Controls imposed at a state or local level may have the net impact of achieving specific environmental, health or safety goals at the cost of state or local economic activity, as individual firms or whole industries move to areas with fewer regulations and restrictions on their activities.
Regions, states and localities astute enough, and with sufficient resources, may be able to work with firms and industries and representatives from citizen's groups to fashion solutions acceptable to all parties, but doing so will not be easy.

The net effects of regulations, on farm structure and on different farm types, depend on the extent and nature of the controls, on the ability of individual producers and processors to adapt, and on the institutional environment (availability of labor, education and training). Regulations that require high levels of technical inputs, or large capital investments, or both, will tend to favor larger, more specialized operations, except when the regulations are waived for operations below a certain size. In such cases, smaller operations will be spared the cost of complying with the regulations and will retain their competitive position, or may even gain some advantage, but it will be at the expense of the environmental, health or safety goals.

Command and control systems--regulations and restrictions--are not the only way to address these public concerns, although in the short run they may be the most practical way. Offering incentives for environmental services and making available tradeable pollution or waste disposal permits are other approaches. Considerable work is needed to design and evaluate various programs of these types. Expanding education efforts, raising producers' awareness about the health, safety and environmental consequences of some production practices, and helping them explore and understand alternative methods that are less detrimental may be the most effective and efficient way of dealing with the problems in the long run. Without having the details of any such programs, their net effect on the number of farms and the distribution of farms by size is difficult to ascertain.
G. International Turmoil or World Food Shortages

In a period when excess capacity and surplus grain production have been the main public policy concerns in North American agriculture, food shortages may seem an unlikely prospect. Yet the balance between shortage and surplus is surprisingly delicate, given the world population and the potential for disaster arising from extremes in weather or political upheaval. In the event of a major world disaster, in the form of widespread political strife or a natural catastrophe, food can become a weapon or a tool and speculative pressures can exacerbate problems in an already tenuous situation.

When food is scarce, price levels and variability increase and expectations of increased profitability of agricultural production rise. In the short run, higher commodity prices slow exits from farming. Land is seen as a safe harbor for investment. Longer run adjustments are more difficult to assess, as all sectors, not just agriculture, are usually affected. Historically, periods of war and turmoil have lead to important adjustments and changes in society. As was discussed earlier in this section, the health of and opportunities in the general economy have a major influence on the health of and rate of structural change in the agricultural sector. As important to recognize is the inescapable fact that U.S. agriculture is an integral part of the world economy. What happens outside our borders will affect the entire U.S. economy, including, and perhaps especially, U.S. agriculture. The forces influencing the structure of U.S. agriculture are thus global and continually evolving.
VI. CONCLUSIONS

Minnesota's livestock industries have been shaped by many forces. This report has focused on some of the major forces that have contributed to the changing character of these industries and that are likely to continue to effect change, in Minnesota, in the Upper North Central states and throughout the country as a whole. Whether we like the direction of the changes or not, understanding these forces and their role in the changes that have occurred in the past is a crucial step in preparing for the future. Many of these forces have been in place and shaping trends for years or even decades. Therefore, we can expect Minnesota's livestock industries to continue to change in response to these forces. While the general direction of the change appears to be set and complete reversal of the trends is unlikely, the rate depends on many factors and is, perhaps, more subject to question.

The demand for livestock products continues to change. The rate of population growth in the United States appears to be slowing, a factor that will dampen the rate of growth in demand for agricultural products in general. Changing consumer tastes and preferences will, however, change the mix and character of products demanded, so some products may enjoy a relatively greater increase in demand while others will see demand grow at a relatively slower rate or even drop. Livestock products are, and will continue to be, particularly vulnerable to consumers' increased awareness of and concern about health issues. The continuing desire for convenience also will change the products demanded at the retail level and, thus, the type of product purchased from producers.

The state of the general economy and shifting government priorities will have a major influence on the entire agricultural sector. The general recession currently afflicting the country hits the farm sector as much as any other. The attendent lack of
opportunities elsewhere may have slowed the rate of exit from farming for the time being, but it can be expected to resume at a pace more like that of the 1970s and 1980s when the economy comes out of this recession. It is possible that the rate of exit could even accelerate, with a "wave" of people who have been considering leaving farming for some time, but who had not seen another job opportunity previously, increasing the natural attrition rate. The decline in agriculture's political power will lead to a decrease in the government's monetary support for, but not its regulation of, agriculture. These changes could also increase the rate of exit from farming, especially if farm incomes become more variable and regulations markedly increase production costs.

For the livestock industries, the greatest impacts of these trends and forces will be seen in dairy, beef, hog and poultry. The changes will affect the industries on a nation-wide basis, but they may also change the relative competitive positions of some regions within the country. Consumption of lamb, mutton and veal has been steadily declining for some time now, and the prevailing trends in those industries are likely to continue.

A. The Outlook for Minnesota's Livestock Industries

1. Dairy

Changes in the future demand for dairy products will be largely in the type of product rather than in the magnitude of demand. Consumers are consuming more lowfat milk, less whole fluid milk, and even less butter, due to concerns about cholesterol and animal fats. The increased consumption of breakfast cereals will help maintain the consumption of fluid milk. In general, the demand for dairy products will decrease as the population ages and becomes more ethnically diverse. The increase in food consumed away from home has an adverse effect on total dairy consumption. Cheese consumption may increase, however, since it is a complement to beef, which benefits from the trend toward
more food consumed away from home, and since consumers appear to see cheese as a convenience food.

The Upper Midwest dairy subsector has become less competitive relative to other regions in the U.S. and this trend will likely continue. As a group, Minnesota dairy farmers will continue to face increasing competition from other regions, particularly the Pacific region where the production costs per hundredweight of milk produced are the lowest in the country. The Midwest's share of total production will also slip, as the faster population growth rate in the Sunbelt region stimulates greater demand for, and hence supply of, dairy products. Local production will, however, continue to meet local demand for most dairy products. The potential impact of new technologies, such as bovine somatotropin (bST), on production levels and the relative competitiveness of different size herds is uncertain. The impact of some of these new technologies for Minnesota producers may actually prove to be smaller than the impact of improved genetics and better herd management and the competitiveness of other regions.

These trends seem to point toward contraction in Minnesota's dairy industries in the future. The condition of the state's general and farm economies will influence this trend. A strong state economy will likely hasten farm exits. A strong farm economy in general may, for some dairy farmers, facilitate the move out of dairying and into crop production, thus decreasing the number of dairy farms but not the total number of farms.

2. Beef
The downward trend in beef consumption witnessed over the last fifteen years can be expected to continue. Several factors are contributing to this trend. Consumers are choosing to decrease their intake of animal fats and cholesterol; they have also become more willing to substitute chicken for ground beef, and fast food restaurants now provide more chicken meals. The aging, more ethnically diverse population and smaller average households
also contribute to the declining beef consumption. Although
demand for beef is boosted somewhat by the increase in
consumption of meals away from home, as our society becomes more
educated, quicker to try new foods, and more informed about
health and food safety issues, red meat consumption in general,
and including beef in particular, will likely continue to
decline.

Both the Upper North Central region and Minnesota have lost
beef production and slaughter capacity over the last two decades.
Unless there are unforeseen changes, the rate of decline in
slaughter capacity is expected to decrease, as the entire
national industry stabilizes near current levels. Currently, the
Upper North Central region has ten of the sixty-six slaughter
plants in the nation with an annual capacity of over 100,000
animals. This relatively large share of current capacity bodes
well for state and regional producers—especially those in
southern and western Minnesota who are close to several of these
plants.

For the next few years, the number of beef cows in Minnesota
is expected to decrease. USDA estimates of production costs show
large beef cow operations to have advantages over smaller
operations and producers in the West and Great Plains to have
lower costs than those in the North Central and South regions.
Thus some cattle production will move out of Minnesota to larger
operations elsewhere. If, however, the often discussed proposal
to increase grazing fees on public lands becomes a reality, the
situation could change. Minnesota does not have a large amount
of grazing on public lands, so producers here could see their
competitive position improve while producers in the western
states where public land grazing is important would see their
costs rise.

The future for beef feeding in Minnesota is uncertain since
it has not yet stabilized onto a clear trend. USDA estimates of
production costs show a widening gap between farmer and
commercial feedlots. Thus, within Minnesota and nationwide, we
can expect a gradual shift toward larger operations. With the current level of slaughter capacity, we can expect total production in Minnesota to remain at about current levels for the near future. Also, the movement toward more feeding in the larger feedlots of the Southern and Great Plains regions appears to have slowed considerably, which relieves some of the competitive pressure on Minnesota producers.

3. Hogs
Unlike beef, pork has enjoyed a fairly stable per capita consumption pattern, and there is some evidence that it may be increasing. Fresh pork products are accounting for a larger portion of total pork consumption. Nevertheless, the forces that are contributing to the decline in red meat consumption overall will also influence pork consumption and its share of total meat consumption has been decreasing over time. While the pork industry has not faced the same adjustment difficulties as the beef industry, pork consumption cannot be expected to increase greatly in the future.

The Upper North Central region leads the nation in hog production and holds a strong and strengthening position in hog slaughtering. According to USDA estimates, the costs for farrow-to-finish operations, feeder pig production and finishing feeder pigs in this region are lower than in the other major producing region, the Southeast. This dominance helps ensure a fairly stable future for the region's industry as a whole. There are, however, forces that may change the structure of the industry. Smaller operations in all phases of pork production have higher costs than larger operations, so the shift to larger operations is expected to continue. In Minnesota, the hog slaughtering plants are located in the southern tier of counties just across the border into Iowa and South Dakota; thus, the producers near these plants have a competitive edge over producers in other parts of the state.
The newest force that may increase the rate of change in hog production is contract feeding. These contracts between meat companies and farmers ensure the contracting packer a supply of hogs with certain qualities. The contracts are usually for a large number of hogs and for extended periods. Proponents of these contracts and large operations say they are the logical step to maintain competitiveness for both individual farmers and regions. Opponents see them as the beginning of greater concentration in, and industrialization of, hog farming.

The differences in consumption, production and processing patterns suggest that changes in the pork industry will not exactly mirror those in the beef industry. It is less likely that hog feeding will leave Minnesota and the Upper North Central region, because the feeding advantage is stronger and slaughter capacity is greater for hogs than for beef. The trend toward larger operations, however, will continue into the future. Management of large hog operations has improved significantly in recent years, thus removing one of the constraints on the expansion of larger operations.

The outlook for Minnesota's hog industries could prove to be less optimistic if certain factors act in concert. For example, stringent state environmental regulations could discourage expansion of large hog operations here, in effect pushing them to western states. The situation would be exacerbated if a processor now located in close proximity to Minnesota's hog producers were also to move its operations west to serve the new producers there.

4. Poultry
Chicken and turkey consumption has increased dramatically during this century. About 90 percent of total meat consumption is now shared almost equally among chicken, beef and pork, with turkey holding the largest share of the remaining 10 percent. Most of the increase has come in the form of cut-up chicken and turkey, not whole birds. Consumers have seen poultry meat as an answer
both to health concerns and to the desire for convenience. Poultry processors responded more quickly to consumers' desire for greater convenience and have thus been the ones who reaped the benefits of that trend. Poultry has also benefitted from increased income and the increase in dining away from home. The consumption of eggs has decreased with the aging population and due to health concerns, but is expected to benefit from the greater ethnic diversity in the population.

Broilers and turkeys are primarily produced by farmers under contract with processors. While the future of the industry in the Upper North Central region looks quite bright, some adjustments are still occurring. The recent closing of the turkey processing plant in Detroit Lakes, Minnesota, is one example of these adjustments. If this plant closing signals the beginning of a shift of turkey processing out of Minnesota, it may also signal the potential beginning of declining turkey production in the state. If, however, other processors expand and pick up the processing capacity, the closing of the Detroit Lakes plant may have only a slight effect of Minnesota turkey producers in the long run.

B. Future Research Needs
In reviewing the changes in Minnesota's livestock industries over the past decades and looking forward from that historical review, we can see that there are several areas in which detailed information is lacking. As these industries evolve, so must our knowledge about them grow if we are to make informed decisions about regional competitiveness, plant capacities and locations, policy options for the entire agricultural sector and the various segments of it, and the development of new agricultural products.

One area in which there is a pressing need for more research in the future is that of estimates of production costs for operations of different sizes. Clearly, Minnesota and the Upper North Central states have seen their relative position in dairy,
beef and hog production change over the past thirty years—sometimes to their advantage, sometimes not—because relative production costs have changed. Some of the change is due to changing relative input costs, and this area is another in which more work is needed, but some is also due to structural changes within the industries in different regions of the country.

Another segment of the industry that has witnessed major changes over the years is processing. Trends in processing tend to be at the national level, but they certainly affect the state and regional producers. Questions of optimal plant capacities and locations for dairy, beef and poultry processors need to be addressed. The closing of the Detroit Lakes plant indicates the need for further study of the turkey processing industry in particular.

In the area of management and policy options, several specific items seem to warrant further consideration. For Minnesota beef cow/calf operations, alternative management options for spatially separated pasture tracts need to be compared. In hog production and processing, enquiry into several issues should be pursued. The practice of contract feeding seems to be catching on in Minnesota. We need a greater understanding of the financial commitments involved in contracting, and of what a producer entering into a contract feeding agreement needs for protection and to maintain competitiveness. Some analysts suggest that farrowing in southern states and then finishing the hogs in the Upper North Central region may prove to be advantageous in the future. The implications of such a separation of activities need to be explored. Particularly important is the question of possible job losses if the bulk of farrowing—the more labor intensive phase of hog production—were to take place in another state. In Minnesota, there was some discussion of setting, legislatively, a maximum size for hog operations. The legislative discussion has been replaced, more recently, by local policy discussions centering on whether localities should grant permits for larger production units.
Before the implications of such policies can be examined, we need to know what the size limit would be and the estimated costs of production for operations of that size compared to the costs of production for larger operations, and whether larger operations are permitted in other localities and states.

The poultry industries have witnessed dramatic changes in consumption, processing and production. Many people view broiler production as more akin to manufacturing than to farming, and it has its proponents and opponents. What the future holds for turkey production and whether it will follow the trends in the egg and broiler industries are questions that warrant attention in the future.

In the mid-1980s, at the height of the recession in agriculture, there was much talk of the development of new products from agricultural commodities. These new products included non-traditional and even non-agricultural products, such as industrial and pharmaceutical end products. Most of the attention was focussed on products from crops, but there are avenues to be explored that could yield new products from, or new uses for existing products of, the livestock industries. In order to keep up with an ever-changing world, we need to keep looking for new processes, new policies and new products that will enhance agriculture's place in the larger economy.

C. Closing Comments

In closing, we return to a comment made earlier in the paper about the distinction between broad, industry-wide trends and the experiences of individuals. This paper has focused primarily on broad trends. These trends suggest that Minnesota's livestock industries cannot, in general, expect to see strong growth in the coming years. Some industries will enjoy more growth than others. And, of course, some individuals within each of the state's livestock industries will buck the flat or downward trend of their particular industry and prosper. The citizens of Minnesota must decide what sort of structure they want for the
state's livestock industries in the future. If they do, indeed, want viable, competitive livestock industries, then it is those individuals who have shown that they can forge their own paths who should be encouraged and from whom much can be learned.
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