Dynamics and Trends in the U.S. Dairy Industry

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ABSTRACT

Fueled by economic forces, dairy sector policies, technological progress, and strict environmental regulations the U.S. dairy industry is consolidating into large, confined animal feedlot operations (CAFOs) and concentrating in a few localized areas. These structural changes produced a disproportionate impact on the local areas, exacerbating local dairy waste pollution problems because of introducing manure nutrients at a rate far in excess of environmental assimilative capacity. The national, regional, and state-level trends in the dairy industry are examined, with the objective of identifying forces that are responsible for this structural change. The structural change will create winners and losers among traditional dairy farms, rural communities, and environmental integrity. Therefore, public policy has an important role to play in balancing the cost of a changing dairy industry with the benefits to society at large from a more economically efficient and environmentally sound industry.

DYNAMICS AND TRENDS IN THE U.S. DAIRY INDUSTRY

The dairy industry is a significant part of the U.S. agricultural sector. Receipts from the sale of dairy products totaled $20.2 billion in 1990, accounting for nearly 11.9 percent of total cash receipts from farm marketings (USDA 1992). Even though the share of receipts from dairy products has remained stable since 1980, at approximately 12 percent, the dairy industry per se is undergoing significant structural change. The structural change is fueled by fundamental economic forces, government pricing policies and supply control, technological progress, and environmental protection. In particular, the dairy industry is consolidating and concentrating to remain efficient and profitable amidst various destabilizing market and nonmarket forces. According to the most recent agricultural census, the proportion of commercial dairies with fewer than 50 cows per farm decreased from 99 percent in 1950 to about 66 percent in 1987, while the average dairy herd increased from about 6 cows per farm in 1950 to more than 50 cows per farm in 1987.

Another noticeable trend in dairy industry dynamics involves increased regional disparities and heavier concentration in selected farm production regions of the U.S. Department of Agriculture (USDA). The regionalism that developed in the dairy industry during the 1980s can be attributed in part to shifts in production levels between traditional dairy farms and the specialized drylot dairies. Two distinct producer segments exist in the dairy industry. First, there is the traditional self-sufficient dairy farms that produce a significant share of their feed requirements. These are typically smaller dairies that farm more land than is needed for waste disposal. The second segment includes specialized drylot milk producers who only grow crops as a byproduct of waste disposal and purchase the bulk of their feed requirements. These typically large operations concentrate on producing milk at the lowest possible cost. Recognizing the significance of this dichotomous structure is essential to understanding the forces that influence the future structure of the dairy industry.

Thus, the trend toward increased concentration and consolidation of dairies has had a disproportionate impact on a few local areas of the country, raising major concerns in those areas over potential surface and groundwater pollution. For instance, Tulare County, California; Erath County, Texas; Jerome County, Idaho; and a few other counties in Florida, Washington, New Mexico, Arizona, Utah, and Oregon are experiencing significant increases in cow numbers, both from

the entry of new firms and expansion of existing firms. This expansionary trend exacerbates dairy waste pollution problems in those areas because of accelerated dairy activity, which may introduce pollutants at a rate far in excess of the environmental assimilative capacity. Erath County, Texas, is a notable example of the relationship between environmental degradation and the national trend toward increased consolidation and concentration in the U.S. dairy industry (Jones et al. 1993).

This report examines the national-, regional-, and state-level trends, with the goal of identifying potential areas in the country that could experience significant dairy waste management problems. The trends in milk production (total and average), absolute and percentage increase in milk production, number of milk cows, number of dairy farms and number of milk cows per farm, average herd size distribution, regional and top ten milk producing states' share of milk production, and the relative shifts are examined. Furthermore, this report identifies key economic forces contributing to structural adjustments, including the economies of size, regional disparities in cost of production and residual returns to management, and government programs and policies.

Appendix A provides a county-level analysis of dairy waste (manure) production and manure nutrient (total Kjeldahl nitrogen and total phosphorous) accounting using typical engineering coefficients of manure production and characteristics (ASAE 1993). This manure nutrient accounting method helps in identifying counties where manure nutrient production exceeds crop nutrient assimilation. Consequently, it helps to identify areas of the country experiencing major dairy concentrations, and that would be more likely to have water quality impairment caused by dairy waste even if there were no direct discharges of dairy waste to waters of the United States.

The structural realignment underway in the dairy industry will ultimately result in fewer, larger, and more competitive dairy farms. The structural shift will also create winners and losers among traditional dairy farms, rural communities, and environmental integrity. Many small dairies will be crowded out. Economic activity will rise in some rural communities and fall in others as the industry concentrates in fewer pockets. As concentration increases, livestock wastes become an increasing environmental concern. Thus, a public policy challenge emerges to balance the costs of a changing dairy industry with the benefits to consumers from a more efficient industry that produces high-quality products at the lowest possible cost, including the cost of environmental compliance.

Dairy Dynamics and Trends

National Trends

Beginning in 1949 with the introduction of the Dairy Support Price Program, the U.S. dairy industry was changing significantly in its structure, organization, distribution, and productivity. Total annual milk production increased between 1950 and 1992 from approximately 110 billion pounds to 152 billion pounds, while during that period the total number of milk cows declined from 21 million to 9.8 million (Figure 1). Thus, the number of milk cows declined by more than 50 percent, while total annual milk production increased by nearly 40 percent. This phenomenon is attributed to a technology-induced threefold increase in milk output per cow, from about 5,200 pounds to 15,423 pounds (Figure 2). The number of milk cows has been steadily declining, but the total milk production has been steadily increasing; therefore, the current supply is from fewer, but more productive, cows. The technologies responsible for increased production per cow include management techniques, automated feeding and milking systems, confined animal feedlot operations (CAFOs), and biotechnology.

From 1950 to 1987, farms reporting milk cows were consolidating dramatically to take advantage of economies of size and remain competitive in a market experiencing falling and volatile milk prices. During that period, the number of farms reporting milk cows declined by almost 94 percent. The steady decline in the number of farms reporting milk cows is accompanied by a corresponding increase in the size of the remaining milk cow herds; therefore, current milk supply is from fewer but larger herds. The total number of farms reporting milk cows declined from about 3.6 million in 1950 to 0.2 million in 1987, while the average number of cows per farm increased from fewer than 6 to 50 (Figure 3). Figure 4 shows the average herd size distribution of farms reporting milk cows for 1950 and 1987. In 1950, farms with fewer than 50 milk cows represented a 99 percent share of all farms reporting milk cows. However, by 1987 that share declined to 66 percent. On the other hand, from 1950 to 1987, farms with more than 50 cows increased their share from 1 percent to 34 percent. Small dairy farms, which once played a major role in milk production, have been declining rapidly with no end in sight. In summary, the trends in the dairy industry at the national level suggest continued consolidation and concentration. Technological advancements forcing small-sized dairy farms to expand, increases in milk output per cow, increased opportunities for off-farm employment, declining government support, and increased environmental awareness have contributed to the structural evolution that is under way.

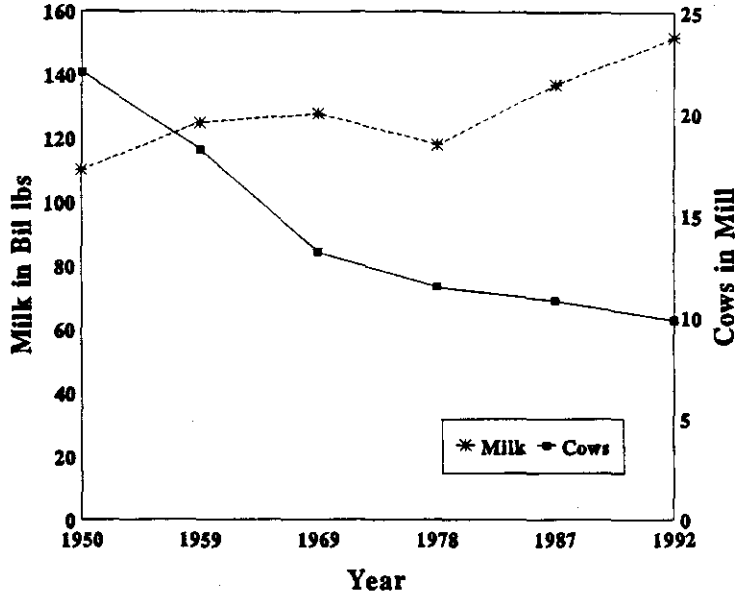

Figure 1. Total annual milk production and number of milk cows, 1950-92
SOURCE: USDA 1993.

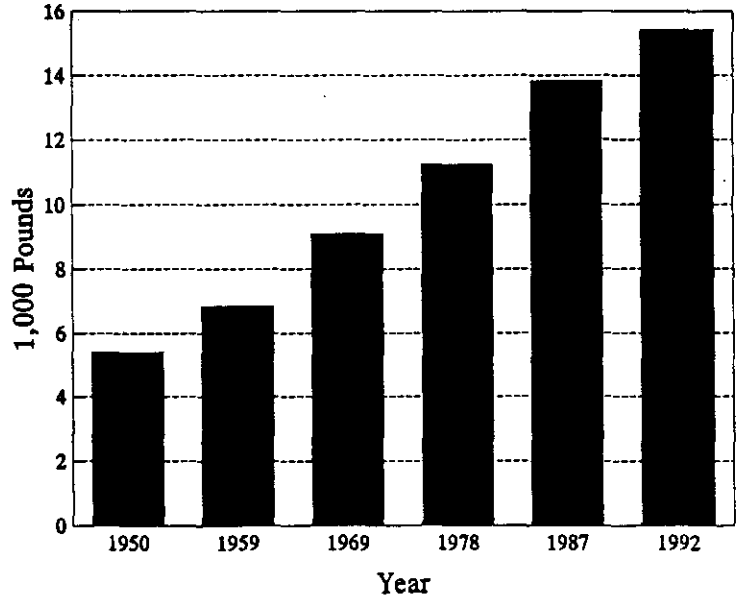

Figure 2. Average annual milk production per cow, 1950-92
SOURCE: USDA 1993.

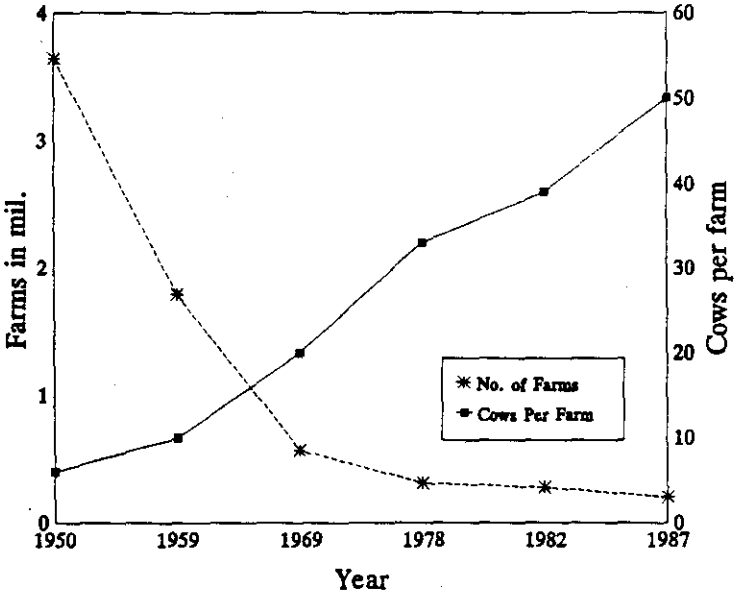

Figure 3. Total number of dairy farms and number of milk cows per farm, 1950-87
SOURCE: USDA 1990.

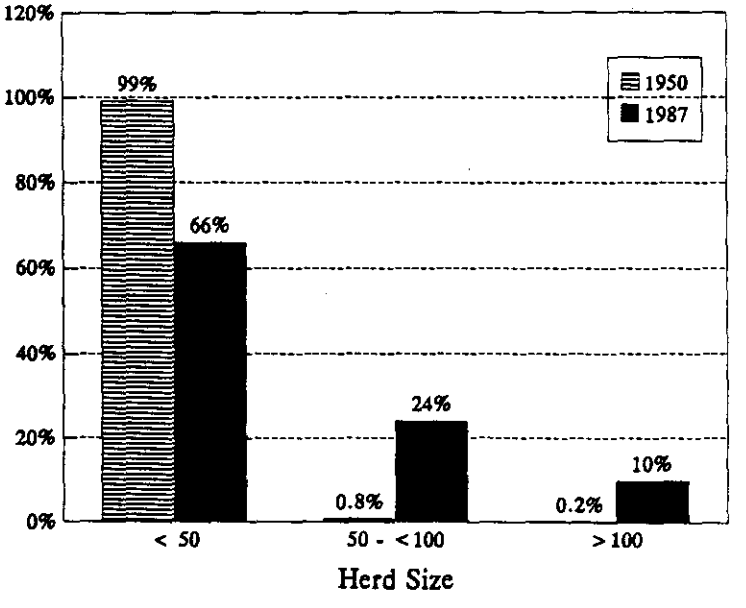

Figure 4. Average herd size distribution of dairy farms, 1950-87
SOURCE: U.S. Census of Agriculture 1987.

Regional Trends

The USDA has grouped the 48 contiguous states into 10 farm production regions. The Northeast and Lake States regions, which include the traditional dairy states of Wisconsin, Pennsylvania, New York, and the New England states, registered a decline in cow numbers by about 2 percent between 1987 and 1992 (Figure 5). The Southern Plains, Mountain, and Pacific regions recorded a 1.5 to 2 percent increase in the number of cows during this period. The gains of the Mountain region are particularly strong. During the same period, milk production per cow increased by more than 2,000 pounds in these three regions (Figure 6). The Southeast region also experienced a significant increase in milk production per cow from 1987 to 1992.

In addition to total milk cows and production per cow, changes in regional shares of total U.S. milk production indicate regional shifts. Figure 7 shows regional shares of milk production for 1965, 1975, 1985, and 1992, while Figure 8 depicts changes in regional shares of milk production between 1965 and 1992. The Southeast, Southern Plains, Mountain, and Pacific regions experienced increased market share during the period. The Pacific region posted a strong gain of about 10 percent, followed by the Mountain region. The share of the Corn Belt region decreased by more than 5 percent. The traditional milk-producing regions, the Northeast and Lake States, maintained their share by posting only a smaller percentage decrease in relative terms (relative to their large production base).

These regional trends suggest heavier concentrations of dairies in the western and southern United States. Warmer climate could be one reason for dairy industry growth in these regions. Population growth in these "sunbelt" areas, potentially increasing the demand for dairy products, could be another reason. Last, comparative economics and environmental regulations could be another factor stimulating unprecedented growth in these regions. With regard to future trends, Weersink and Tauer (1990), using a dynamic partial equilibrium model of the U.S. dairy sector, predict that historical trends in regional structure will continue until the turn of this century. They forecast that the traditional milk-producing regions of the Northeast and Lake States will maintain their share of total milk production, while the Pacific region will increase its share at the expense of all other regions.

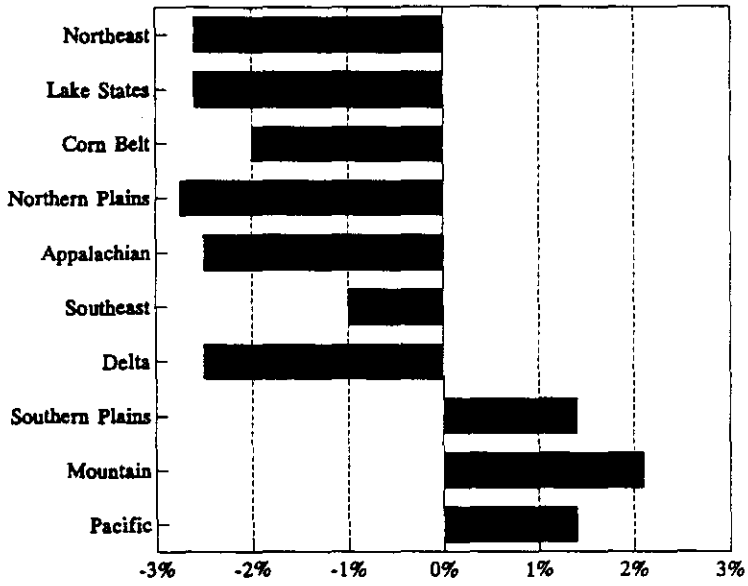

Figure 5. Average annual change in cow numbers by USDA region, 1987-92
SOURCE: USDA 1993.

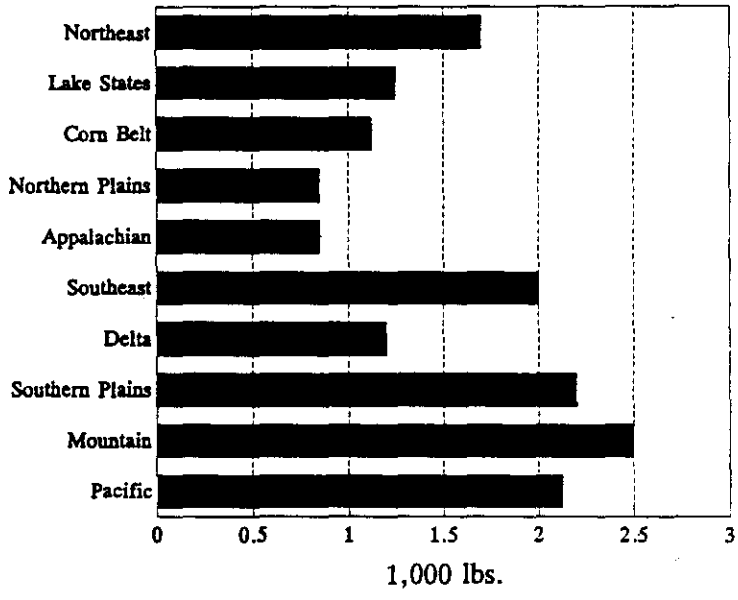

Figure 6. Absolute regional increases in milk production per cow, 1987-92
SOURCE: USDA 1993.

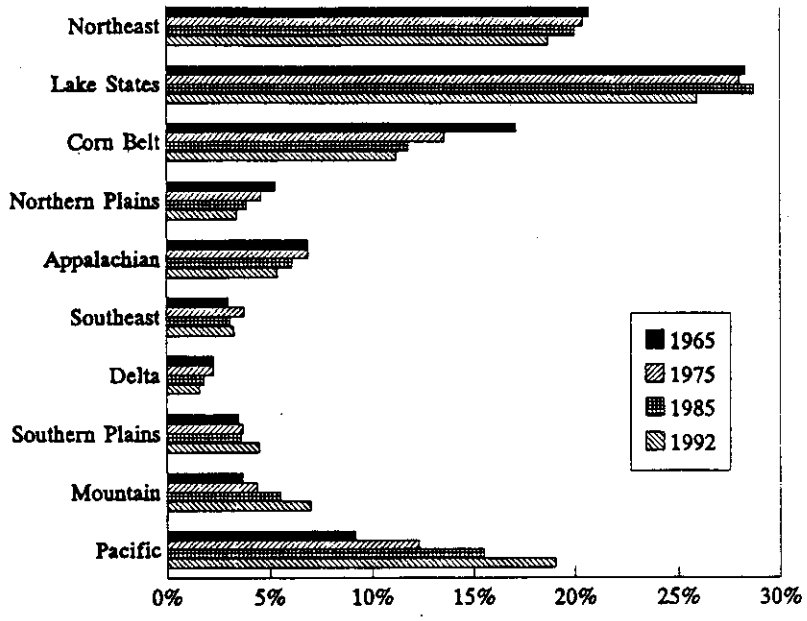

Figure 7. Regional share of milk production, 1965-92
SOURCE: USDA 1993.

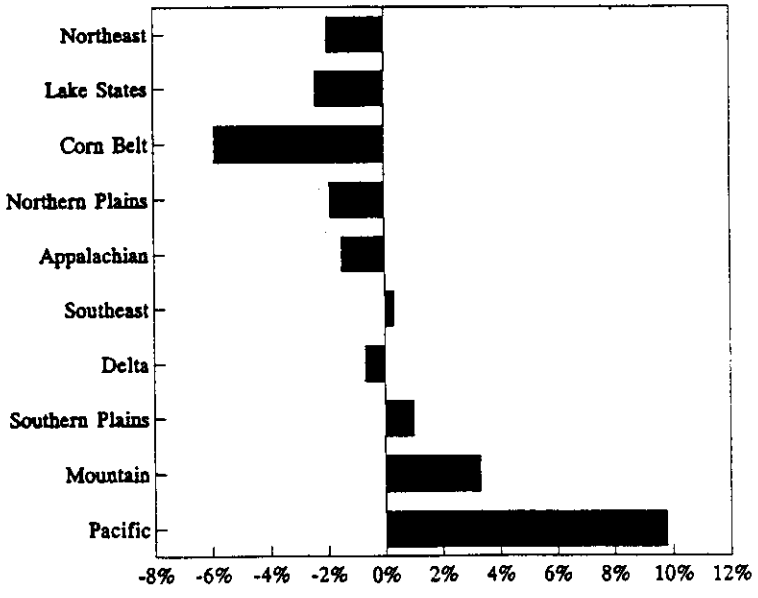

Figure 8. Changes in regional share of milk production between 1965 and 1992
SOURCE: USDA 1993.

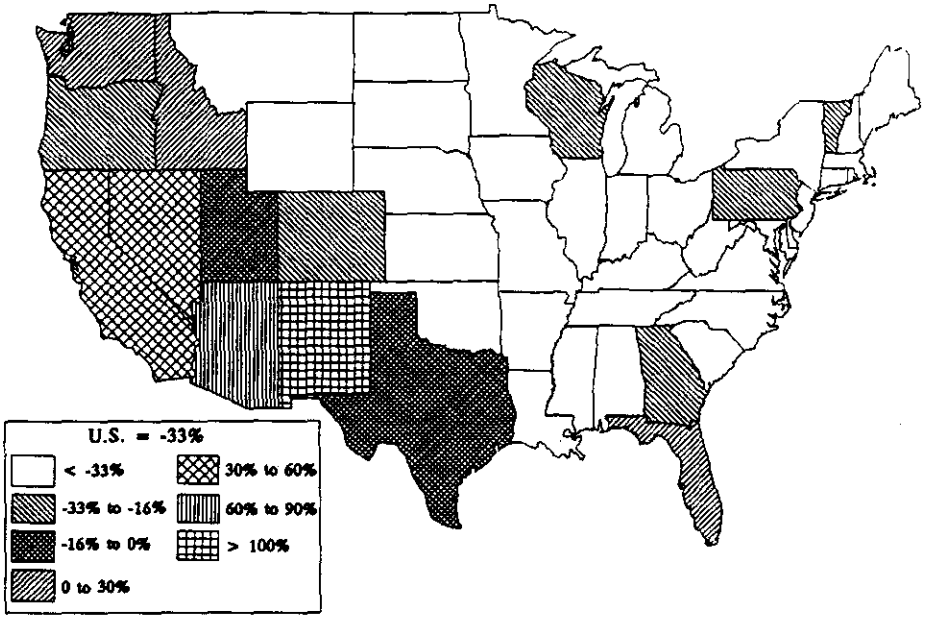

Figure 9. Percentage change in the number of milk cows, 1965-91
SOURCE: USDA 1992.

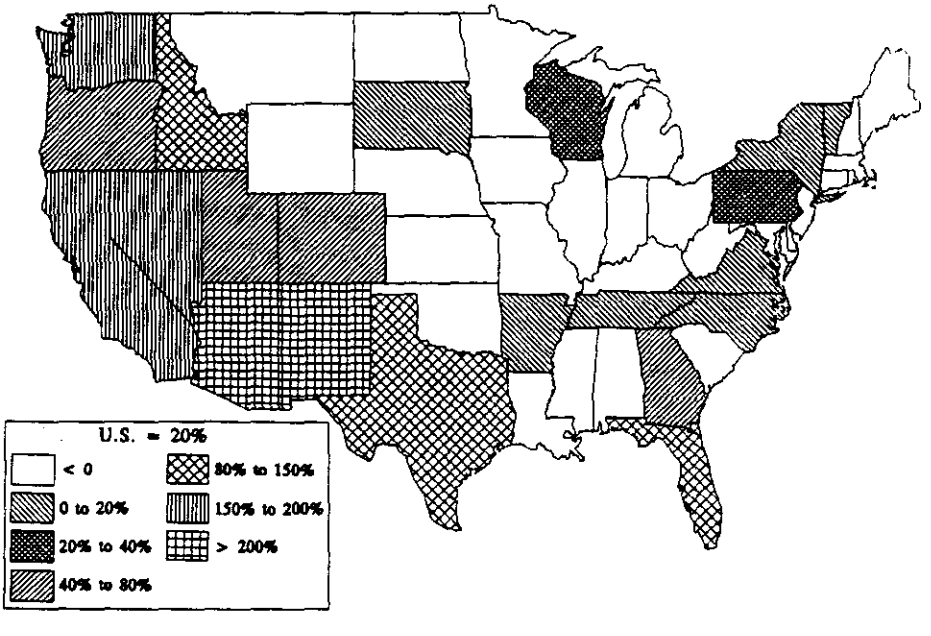

Figure 10. Percentage change in total milk production, 1965-91
SOURCE: USDA 1992.

State-Level Trends

Change in state-level dairy trends—number of milk cows, total milk production, and a state's share relative to total U.S. milk production—was analyzed for 1965 to 1991. Analysis ran only through 1991 due to the unavailability of state-level data beyond that year. Figure 9 is a state-level distribution showing percentage changes in the number of milk cows between 1965 and 1991. New Mexico and Arizona show the largest increase in the number of milk cows (more than 60 percent). California, Nevada, Florida, and Idaho show a 0 to 60 percent increase in the number of milk cows, while states in the Northeast, Midwest, and Great Plains all show a decline in cow numbers. Nationally, cow numbers declined by 33 percent. Utah, Texas, Georgia, Colorado, and Oregon posted only a moderate decline in cow numbers, well below the national average. Figure 10 shows percentage change in total milk production by state between 1965 and 1991. The trend was similar for the number of milk cows, except that the states with a moderate decline in cow numbers showed a strong increase in total milk production. This group of states includes Utah, Texas, Georgia, Oregon, and Colorado. Total milk production decreased in the Midwest, Northern Plains, and the New England states.

Single-year estimates of the distribution of a state's share of total U.S. milk production may be misleading because of the influence of climatic and other factors. Therefore, we examined five-year average milk production between 1965 and 1969 and between 1987 and 1991. Based on these five-year averages, we calculated the share of each state and then computed the change in the share between the two five-year periods. The results are shown in Figures 11 and 12 as changes in the percentage share and as changes in the absolute levels of five-year average milk production. The state of California is far ahead of other states according to both of these indicators, suggesting strong growth in the California dairy industry during this period.

Apart from the concentration of dairies in the western and southern United States, consolidation of smaller dairies into fewer, large dairies is evident nationally. An examination of average cow herd size distribution in the states highlights this fact. Average cow herd size in the top ten milk-producing states in 1991 is shown in Figure 13. The average herd size in California was 275 cows, while in New York, Texas, Michigan, and Washington the cow herd size was above the national average herd size of 55 cows. Figure 14 shows the distribution of dairy farms, by state, with 500 or more cows per farm. All the newly emerging dairy states have a significant number of dairies with 500 or more cows per farm. Nearly 60 percent of the dairies in this category are in California.

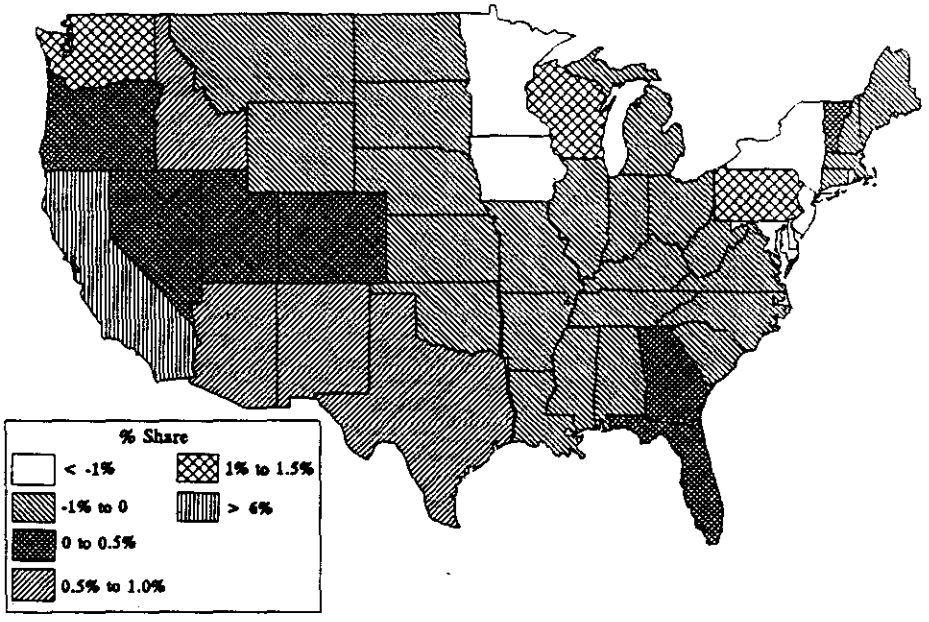

Figure 11. Changes in state-level share of total U.S. milk production between 1965-69 and 1987-91
SOURCE: USDA 1992.

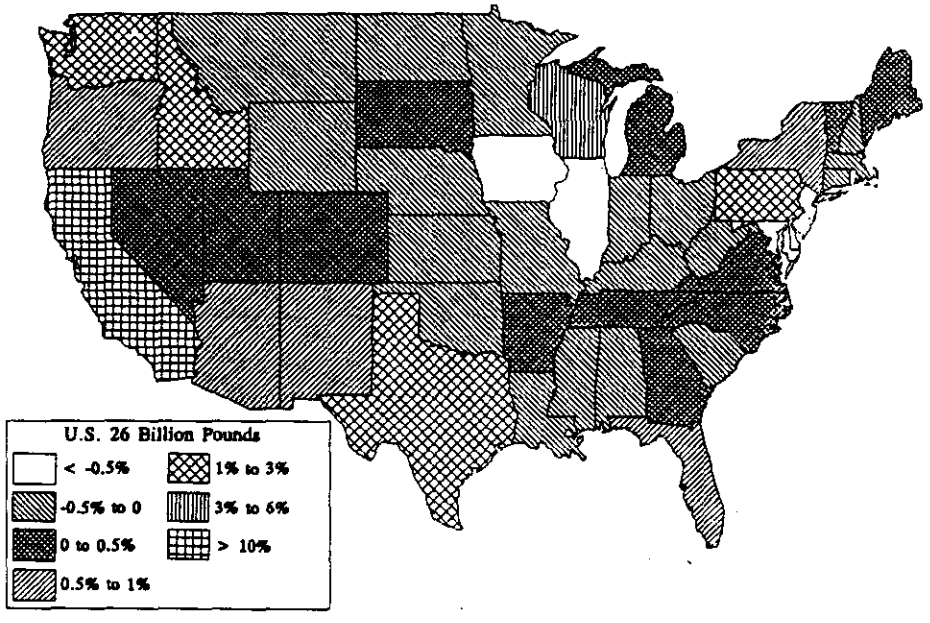

Figure 12. Absolute change in milk production between 1965-69 and 1987-91
SOURCE: USDA 1992.

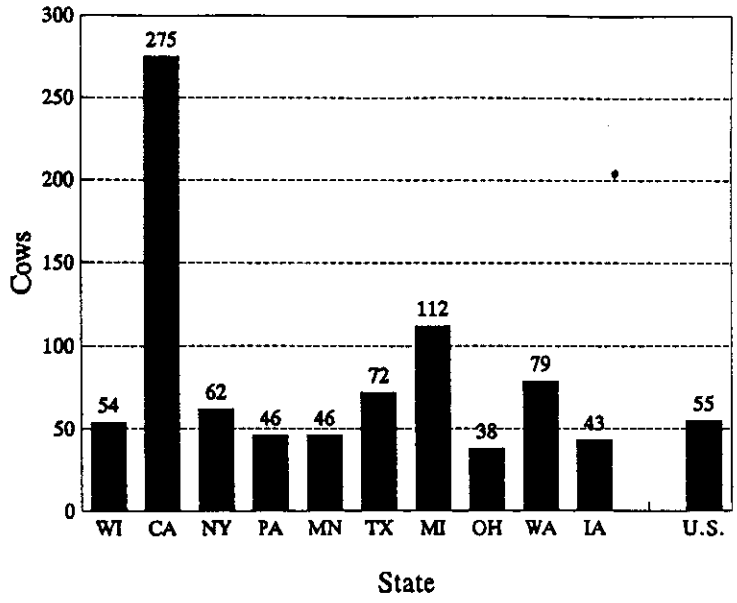

Figure 13. Average size of the farms reporting milk cows in thet op ten dairy states, 1991
SOURCE: USDA 1992.

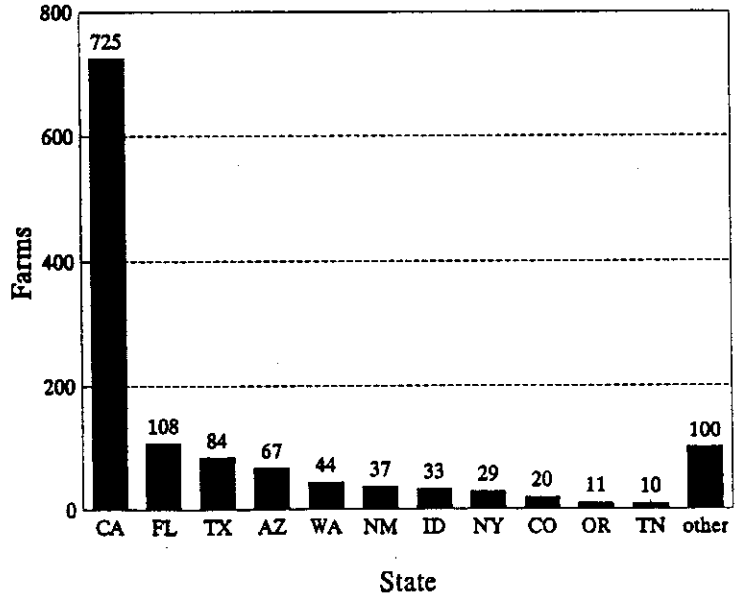

Figure 14. Distribution by states of dairy farms with 500 or more cows, 1987
SOURCE: U.S. Census of Agriculture 1987.

About 9 percent of the dairies with 500 or more cows are in Florida and 7 percent are in Texas. According to the 1987 agricultural census, these larger dairies represent only 1 percent of all dairy farms reporting milk cows, but account for more than 10 percent of total milk cows.

The national, regional, and state dynamics and trends suggest that significant structural adjustments are taking place in the dairy sector. These trends will likely continue at least until the year 2000. Novakovic, Bills, and Jack (1991) project that "if milk consumption only keeps up with population growth of about 1 percent per year and production per cow grows at its historical average rate of about 2 percent per year, cow numbers must decline almost 10 percent by the year 2000. And, if farm size moves up to an average of 75 cows per farm, the number of farms in the U.S. would, by inference, decline about 40 percent" (p. 10).

A time series of annual total milk production from 1973 to 1992 is shown in Figure 15. The base year is 1973 to provide at least 20 years of data; and further, during the 1970s milk production grew at a fairly constant rate. A simple linear trend equation ($Y = a + bT + u$), with year as the trend variable (T), was fitted to explain the annual changes in total milk production (Y). The linear trend model fitted to the whole period (1973 to 1992) gave a highly significant trend coefficient (significant at the 1 percent level of confidence) and an adjusted R-square of 96 percent. The trend coefficient suggests a 2.048 billion pounds average annual increase in milk production.

The cost of federal dairy programs (as reflected by government stocks of milk products) reached a peak in 1983, forcing policymakers to initiate a reduction in the milk support price. Since 1983, the federal policy of minimal intervention and support price have resulted in greater price fluctuations. From 1983 to 1992, milk production experienced a downward shift and a flatter growth compared with the first half of the time series (1973-82). To examine this hypothesis of a downward shift in milk production during the 1983-92 period, a test of the null hypothesis that the milk production was the same in both periods was performed. The test provided an F value of 4.756, rejecting the null hypothesis at 95 percent confidence interval. This result indicates that there was a shift in milk production between these two periods. Also, the trend coefficient suggests an average annual increase in milk production equal to 2.296 billion pounds during the first period, while during the second period the average annual increase was only 1.386 billion pounds. However, the average annual milk production per cow showed no significant shifts in the trend during these two periods (Figure 16). The econometric time series results reinforce the conclusion that the dairy industry is undergoing significant consolidation and concentration, and that the pace of the structural adjustment

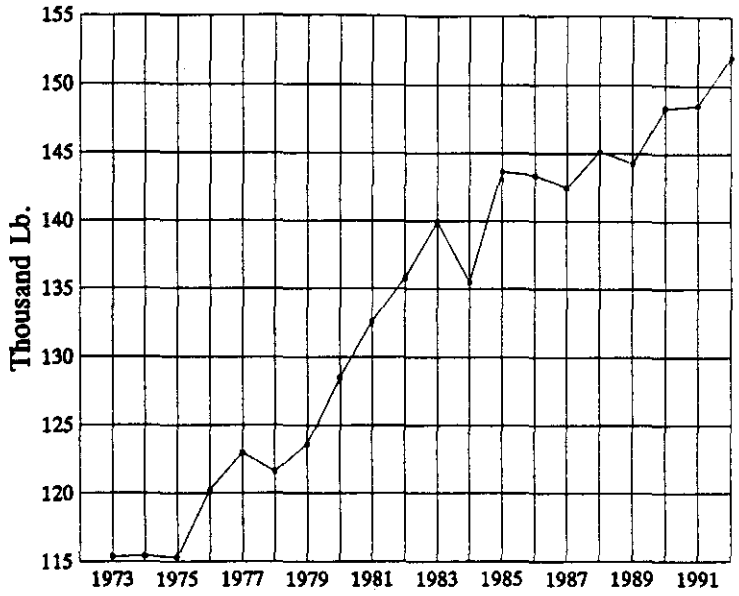

Figure 15. U.S. total annual milk production, 1973-92
SOURCE: USDA 1993.

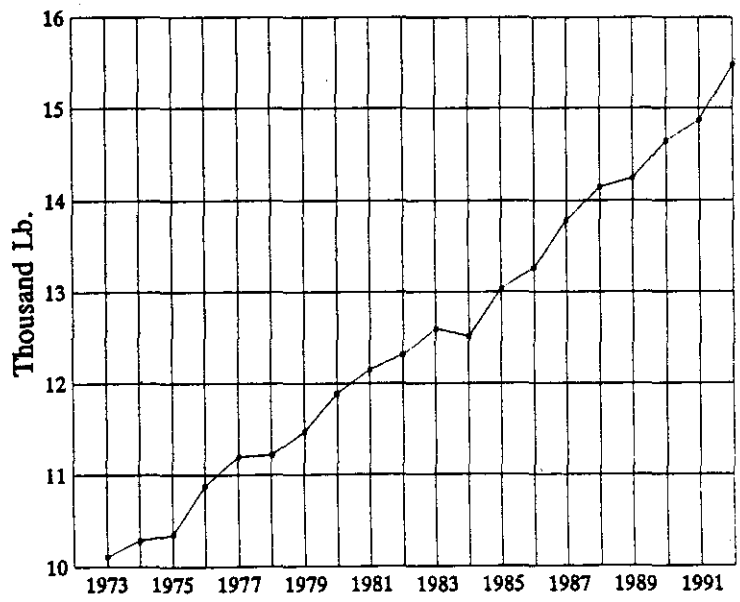

Figure 16. U.S. annual milk production per cow, 1973-92
SOURCE: USDA 1993.

was strong in the late 1980s. The environmental consequences of increased concentration of dairies and/or animals within a smaller geographical/spatial area is yet to be fully understood. However, preliminary studies in Chino Basin, California; Lake Okeechobee, Florida; Lancaster County, Pennsylvania; and Erath County, Texas, all indicate a strong correlation between intensive dairy operations, including CAFOs, and point and nonpoint source pollution of water resources.

Forces Causing Structural Changes in the U.S. Dairy Industry

Consolidation and concentration of the dairy industry is a major economic and environmental issue at present, given the unprecedented levels of consolidation and concentration that have occurred during the mid- to late 1980s. Much of the concern is related to the issue of "efficiency"—both economic and environmental efficiency. Increasing the size of an operation brings economies of size/scale, lowers long-run average costs of production, and enhances "market power" to influence feed and milk prices and other terms of exchange. Research is urgently needed to examine these issues that contribute to the current structural change. Such research might clarify whether structural change is purely a consequence of economic and market forces, or whether environmental forces may be at work.

Both the traditional dairy farmer and the specialized drylot milk producer are experiencing economic pressures to grow. The major forces that contribute to current structural changes in the dairy industry can be classified into: (1) technological change; (2) economies of size; (3) regional differences in costs of production and returns to management, and other comparative advantages; (4) changes in demand; (5) federal milk marketing order and milk support-price policies; (6) climate and weather-related factors; and (7) environmental factors. A brief discussion of each of these forces and other related market and nonmarket factors contributing to the consolidation and concentration of the U.S. dairy industry follows.

Technological Change

The trend toward larger dairies has accelerated in the 1990s as the latest production technologies have transformed the traditional milk shed into a specialized dairy factory. Increases in milk output per cow have not been automatic. They reflect the continuous adoption of new technologies by farmers. Technological changes, including (1) CAFOs, (2) automated feeding and milking systems, (3) increased use of computerized accounting and monitoring of feed rations, (4)

improved dairy herd management through sound breeding and close monitoring of feeding, (5) improved waste management systems, (6) advances in milk processing and handling, (7) artificial insemination, and (8) emerging biotechnologies, including cell culture, recombinant DNA techniques, and external injection of the protein hormone bovine somatotropin (bST) to improve productive efficiency in lactating cows, have contributed to the dynamics and the trends in milk production (OTA 1991). Observers generally believe that increased productivity and increases in milk supply are a consequence of technological change and a favorable milk-to-feed price ratio.

Blayney and Mittelhammer (1990) decomposed milk supply response into technology and price-induced effects in a case study for the state of Washington. The authors conclude that price effects were overwhelmed by technology effects, resulting in milk output expansion despite milk and feed prices signaling supply reduction. They attribute the 2.6 percent expansion in annual milk supply to production function shifts and efficient feed allocation in response to technology-induced opportunities. This result implies that substantial changes in milk or input prices are necessary to induce a drop in milk production. To slow this technology-induced growth in milk supply while simultaneously protecting the environment, government intervention may be called for. For example, limiting herd size by requiring permits for expanding the size of dairies beyond certain threshold levels might be considered. In order to minimize or eliminate violation of permit conditions, severe penalties need to be stipulated. Site-specific threshold limits are usually determined by taking environmental and weather-related factors into consideration. The two voluntary, supply reduction programs of the mid-1980s, the Milk Diversion Program (MDP) and Dairy Termination Program (DTP), were part of the federal effort to reduce supply.[1] These programs, however, were not cost effective (Dixon, Susanto, and Berry 1991).

Differences in productivity per cow across the nation have been associated with climatic conditions, but the main factors seem to be technological progressiveness and quality of management. These factors, in turn, are related to the availability of extension education, consultants, and the infrastructure of input and technology suppliers. Successful technology adoption will be one of the key factors determining future milk production patterns. Some of the other factors affecting these patterns include dairy policies, environmental policies, water availability, population pressures, climate, and resource availability.

Economies of Size

Economies of size, defined as reduced per unit cost of production associated with increased herd size, is widely recognized in the dairy industry. Matulich (1978) examined long-run average cost curves (LRAC) of California dairies, which include milking, housing, and feeding technologies. Matulich found that milk production costs per cow decline substantially as herd size increased from 375 to more than 450 cows, with more gradual economies of size experienced as dairies expand in size to 1,000 cows. The Office of Technology Assessment, USDA (1991) examined the 1985 costs of milk production in relation to herd size for 10 states. According to this study, Minnesota, Pennsylvania, and New York showed the highest cost for small herds (as high as $18 per hundredweight). The cost dropped to $13 per hundredweight for 600-cow herds in California, Arizona, and declined further to approximately $12 per hundredweight for 1,000 to 1,400-cow herds in California and Arizona. As seen previously in Figure 14, the Sunbelt states report the lowest production cost; these states also contain most of the nation's large dairies. The traditional milk-producing regions—the Northeast and Midwest—do not exhibit the same level of economies of size as the Sunbelt. However, this regional disparity may be explained by higher capital costs incurred by the traditional dairy regions for providing heat insulated structures.

Clearly, there are economies of size in the dairy industry. Contrary to the U-shaped LRAC suggested by economic theory, available empirical evidence (Matulich 1978; OTA 1991) suggests a rectangular hyperbola-shaped LRAC. This fact suggests that large dairies may be positioned to internalize a large portion of the environmental costs represented by environmental regulations while maintaining economic efficiency.

Economies of size and economies of scale (technological efficiencies that account for differences in economic performance across dairies) are cited as prime factors motivating consolidation of traditional, small family-operated dairies into fewer, large commercial dairies. Weersink and Tauer (1991) examined the causality between dairy farm size and productivity for the contiguous 48 states using multivariate Granger-causality test.[2] The authors found the direction of causality to be more from herd size to productivity, and not the other way. Their results suggest the existence and exploitation of economies of size by larger dairies in those states. Studies by Jesse (1987) in the traditional dairy state of Wisconsin and Bravo-Ureta and Rieger (1991) in the New England states, found no technical, economic, or allocative efficiency from larger dairy herds.

Economies of size are limited in the northern states relative to the warmer southern and western states because of the elaborate housing required for dairies in the north.

One implication from these results in terms of current dairy economic and environmental policies is: Increased environmental costs of compliance, coupled with declining dairy price supports, have placed a significant strain on smaller dairies, forcing them to find ways to increase productivity. Obviously the dairies expanded in size, exploiting the scale and size economies, in achieving needed productivity increases and economic efficiency.

Regional Differences in Costs of Production and Returns to Management

Regional differences in economic costs and returns and other regional comparative advantages will force dairies to concentrate heavily in certain regions. Figure 17 shows the regional distribution of cash receipts and expenses as dollars per hundredweight for 1990 (USDA 1992). Nationally, cash receipts (receipts from the sale of milk and cattle) for dairy farms averaged $14.85 per hundredweight, while the total economic costs (cash expenses plus fixed costs) were $14.74 per hundredweight, leaving a net average return (residual returns to management and risk) of $0.11 per hundredweight. At the regional level, only the Pacific, Southeast, and Southern Plains regions posted positive returns to management and risk. The remaining regions posted negative returns, with the Corn Belt region posting the largest negative return of $0.69 per hundredweight.

Fixed cost represents another indicator of regional differences. In the Pacific, Southeast, and Southern Plains regions, average fixed costs are smaller than in other regions, suggesting that dairies in these regions are able to spread out fixed costs over large operations, thus taking advantage of economies of size. A comparison of residual returns to management between 1989 and 1990 across the regions is shown in Figure 18. The Pacific, Southeast, and Southern Plains regions consistently reported positive returns during the period.

Milk Marketing Orders and Milk Support Price Policies

Receipts from fluid milk sales represent the bulk of dairy farm receipts (90 percent). The price of fluid milk is determined by government policies and supply and demand, the latter exhibiting significant seasonal fluctuations. Since the federal government first intervened in milk markets more than 50 years ago, a major objective of federal dairy policies has been to ensure an adequate milk supply. To achieve this objective, two interrelated programs have been implemented to directly affect

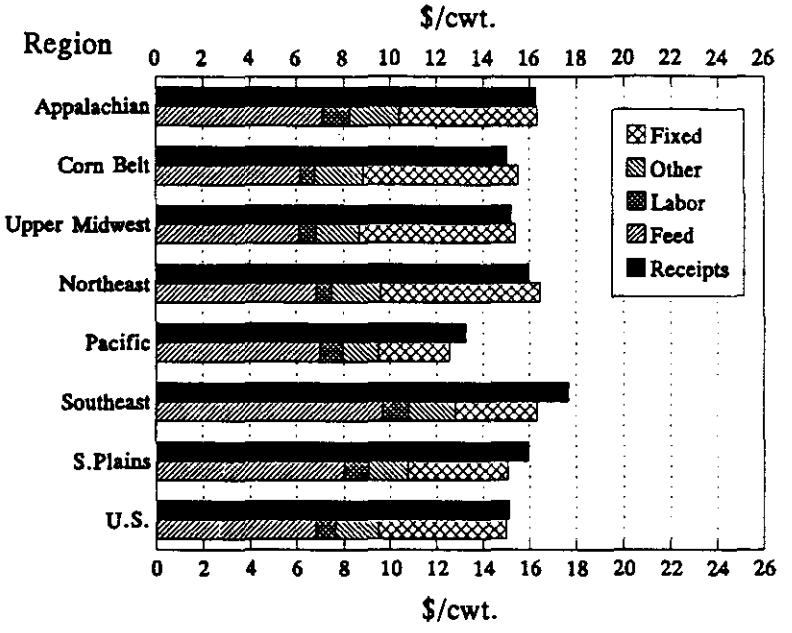

Figure 17. Average cash receipts and expenses by region, 1990
SOURCE: USDA 1991

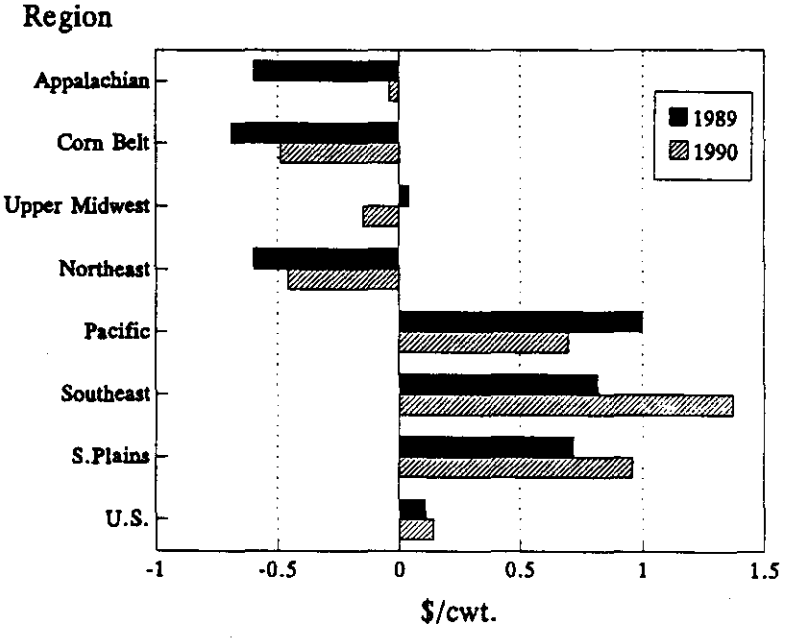

Figure 18. Residual returns to management and risk by region, 1989 and 1990
SOURCE: USDA 1991.

the dairy industry's ability to generate sufficient supply: the support price and the milk marketing order (MMO) programs. These programs have proven so successful in stimulating production that the dairy industry has consistently produced considerably more milk and dairy products than consumers will buy at prevailing prices. Excess production has led to heavy government purchases. Concerned by spiraling government purchases, the federal milk pricing committee instituted seven reductions in the support price starting in 1983. Because of the uncertainties introduced by progressive support price reductions, as the stocks increase to a certain threshold, the price of fluid milk has been more volatile recently (Figure 19).

Federal MMOs and the support price policies work in conjunction to stabilize milk supply and set a floor price for milk. Specific objectives of the MMO program can be summarized as: (1) to promote orderly marketing in fluid milk markets, supervise the terms of trade, and ensure equity in bargaining between producers and processors; and (2) to stabilize milk prices and improve the revenue of dairy farmers, while at the same time ensuring consumers of adequate supply at reasonable prices.

The MMO requires that milk handlers pay not less than a certain minimum class price. The Minnesota-Wisconsin (M-W) price establishes the benchmark for Grade A milk price and blend prices throughout the federal MMO system. Two-thirds of the nation's milk supply is covered by the MMO system. The price of fluid milk at various points throughout the country is the M-W price adjusted for a fixed distance differential for transportation. Therefore, the greater the distance the production point is from the M-W base, the greater the order price. Not surprisingly, the newly emerging dairy states are those in the southern and western United States; that is, farther from the M-W base. Producers in these states benefit from both lower production costs and higher prices.

The existing MMO policy benefits producers in some regions of the country at the expense of others. In the long run, increased production in certain regions may trigger reductions in the price support, thereby causing producers in some regions significant economic hardship. For example, the Upper Midwest, which does not benefit from distance differentials and has a relatively high cost of production, could experience reduced profitability from a reduction in the federal price support. Regions with a lower average cost of production and high distance differentials, such as the Southwest, Southern Plains and the Northwest, could become the major dairy regions under the current system.

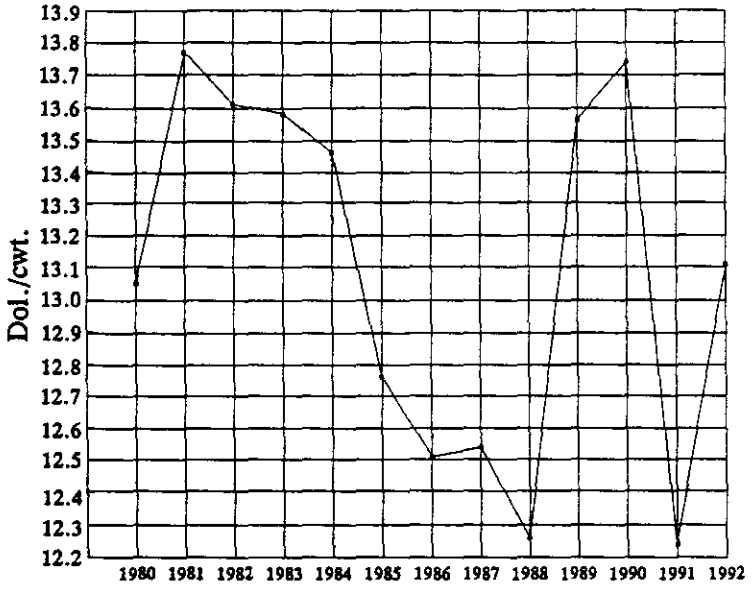

Figure 19. U.S. all milk prices, 1980-92
SOURCE: USDA 1993.

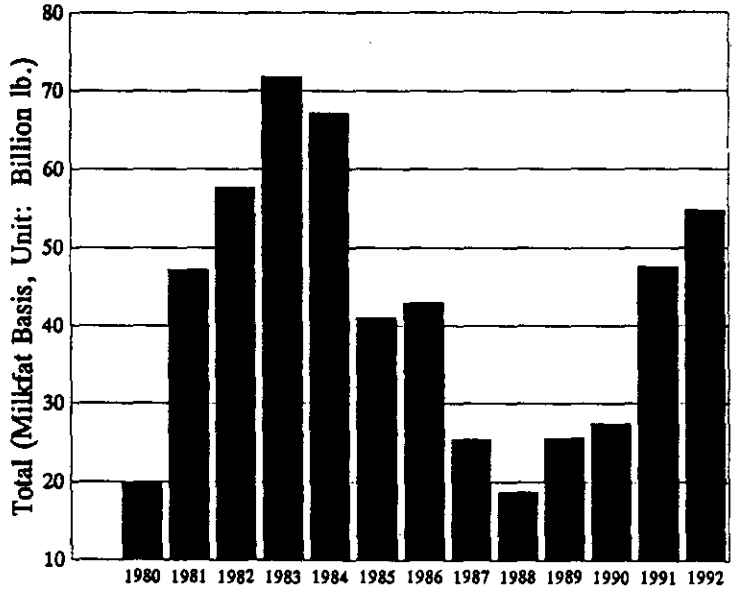

Figure 20. Government dairy product stocks, 1980-92
SOURCE: USDA 1993.

The federal price support program has been influencing federal milk markets since 1949. Under this program, the federal government purchases cheese, butter, and nonfat dry milk in quantities sufficient to maintain market price at the support price level. Through 1980, the secretary of agriculture was charged with maintaining the milk support price at 75 to 90 percent of the milk parity index. From 1954 to 1975, this program brought relative stability to the milk market. However, from 1975 to 1983, the program became extremely costly to the government (as reflected by increased stocks) because of the relatively high support price of milk (Figure 20). To minimize government purchases, the federal government in 1983 initiated the first of seven reductions in the support price of milk. For 1991-95, the support price of milk is set at $10.10 per hundredweight for milk containing 3.67 percent milk fat, with a provision for lowering the support price if the government purchases exceeded 5 billion pounds of milk equivalent. The combination of MMOs, the price support program, and market forces significantly stabilizes producers' revenue.

Climate and Environmental Factors

Weather is an important factor influencing the trend toward fewer and larger dairy farms. For example, low rainfall, low humidity, and warm temperatures are associated with smaller investment in facilities and equipment. fewer herd health problems, lower energy costs for maintenance of animal body temperature, and less labor required for herd care. Emerging technological innovations in dairy housing, nutrition, and waste management offer significant economies of size, particularly for dairy production in warm, semiarid regions. These conditions prevail in only a few parts of the country. More rainfall, higher humidity, colder temperatures, and poorer soil or soil moisture conditions may limit the extent of the economies associated with large-scale dairying.

Environmental issues, particularly point and nonpoint source pollution from dairy wastes, represent another major factor contributing to emerging structural adjustments in the dairy industry. Before passage of section 319 of the federal Clean Water Act (CWA) in 1987 EPA expended the bulk of its resources on controlling municipal and industrial point source discharges under the National Pollution Discharge Elimination System (NPDES) program. Although section 308 of the CWA did call for the development of Areawide Waste Management Plans covering agricultural pollution, limited federal funding effectively stymied the program. However, concerned by the increased share of agriculture in total nonpoint source emissions, as documented in state NPS assessments, a host of

policies and programs are currently being initiated by the federal, state, and local agencies to prevent and abate agricultural NPS pollution.

For instance, the Texas Natural Resource Conservation Commission (TNRCC) allows no discharge from CAFOs except during 25-year, 24-hour storm events and no discharge from manure spread fields. TNRCC regulations also require permits for dairies with more than 250 cows, and do not provide for NPDES delegation from EPA at this time. Similarly, Florida introduced strict nutrient runoff standards for watersheds around Lake Okeechobee primarily to regulate NPS pollution from the dairies in that area. Similar regulations exist in other states, as well, to regulate NPS pollution from CAFOs. Frarey et al. (1993) provide a comprehensive review of policies, enforcement mechanisms, and compliance strategies prevailing in the top ten milk-producing states. In addition to water quality regulations, enforcement of nuisance odor regulations also contributes to prevailing structural adjustments in the dairy industry. While most dairy operations try to satisfy regulatory requirements through adoption of new technologies, profitability and survivability dictate that some operations shift geographically to more favorable locations.

Demand Changes

Changes in demand may be as important as changes in supply in determining the future course of the dairy industry. Shifts in population toward the West and South have favored increased milk production in these regions. Consumption of total dairy products per capita has been declining steadily since 1986 (Figure 21). Declining consumption patterns and increasing production levels will act to depress milk prices, and will force the government to purchase dairy products in order to maintain the milk target price.

Dairy Growth in Erath County

There has been substantial growth in the Erath County dairy industry and the surrounding Cross Timber Region over the past decade. Erath County, with approximately 70,000 cows, is one of the top 20 milk producing counties in the country (TIAER 1992). In 1969, Erath County dairies produced approximately 131.4 million pounds of milk from 13,800 cows. In 1992, Erath County's milk production exceeded one billion tons from approximately 70,000 cows (TIAER 1992). The value of county milk sales in 1991 was estimated at $144 million. Between 1954 and 1987, the

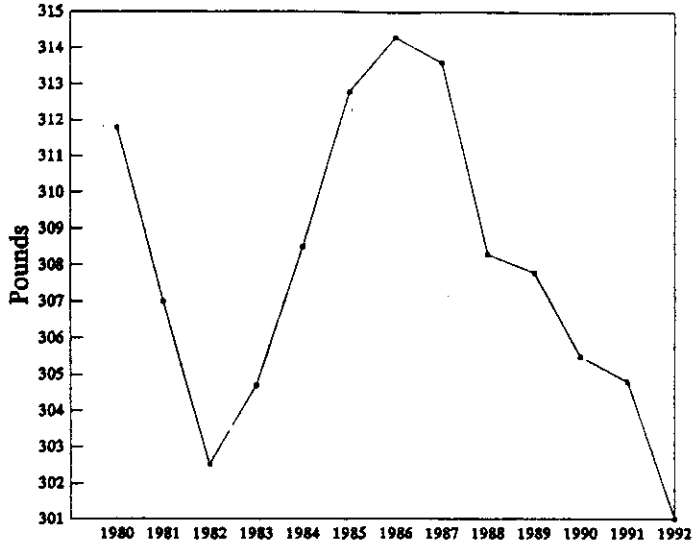

Figure 21. Per capita consumption of dairy products in the United States, 1980-92

number of milk cows in Erath County increased fivefold, while average dairy herd size increased from 7 to 189 cows.

All of the factors discussed earlier in this report were responsible for the growth in the Erath County dairy industry. Tremendous growth came from both an expansion of existing dairies and dairies relocating to the Erath County area from California, Washington, Arizona, and the Netherlands. Favorable price-cost relationships represent one of the reasons for this exodus. Leatham et al. (1992) identify the following key factors that stimulated the expansion and relocation of dairies to the area: favorable markets, technology transfer from other states and countries, dairy pricing policy, dairy infrastructure, and abundant feed supplies. In spite of this heavy influx of large dairies from Western regions, Erath County preserves the dichotomous dairy production structure prevalent in much of the United States.

Conclusions

Throughout the agricultural industry there has been an increasing trend toward production specialization. Traditional family farms raising both crops and livestock in an integrated system are being replaced by specialized, often larger, farm production operations. This is particularly evident in the dairy industry, which currently can be characterized as a dichotomous producer structure of traditional small operations and large, highly specialized operations rapidly adopting new technologies to maximize returns and minimize cost.

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Concurrent with the increase in farm size, dairy producers began to manage dairy cows in small drylots or enclosed buildings to facilitate mechanization and to optimize the genetic potential of their cows through advanced animal husbandry management with a controlled environmental. This resulted in a large concentration of animals on small land areas, producing large quantities of animal wastes. In many cases, point source pollution from dairy lot runoff, and nonpoint source pollution due to runoff and leaching from the intermittent spreading of collected waste on waste application fields, posed a risk to the environment. Additionally, odors emanating from decomposing manure and feedstuffs create obnoxious odors and nuisance effects for nearby residents.

The regionalism that developed in the dairy industry can, in part, be attributed to socioeconomic, market, and policy factors, leading to differences between traditional dairy farmers and the specialized drylot dairies. Government policy clearly plays an important role as it affects the dairy industry through waste management regulations and dairy price programs.

Many Upper Midwest dairy farmers find the present federal milk marketing order unacceptable because of the regional Class I milk pricing disparities based on the M-W pricing formula that guarantees higher milk prices for areas far removed from Eau Claire. The growth of the dairy industry in Texas, Florida, and Washington has in part been attributed by some to federal milk pricing policies. However, these areas also have the greatest population growth, and thus the greatest increase in demand. Since the mid-1980s dairy policy has been continuously evaluated for efficiency. Current industry economic stress, along with technological improvements, free trade agreements, and negotiations, have produced a wide range of policy discussions from eliminating government involvement to production quotas at the farm level.

Economies of size and scale are cited as prime factors motivating the growth and consolidation of the dairy industry. Large dairies gaining economies of size may be positioned to internalize a large portion of the environmental compliance costs required by governmental regulations while maintaining economic efficiency. Regionalization toward the warm, arid climates of the south and west is also promoted by the lower environmental compliance cost associated with these climates. The increasing costs of environmental compliance, coupled with declining dairy price support, have placed a significant strain on smaller dairies, forcing them to find ways to increase productivity.

Based on current trends, it is not obvious that one region will dominate another, only that larger size and specialization will prevail in each region. In the meantime, fragmentation and conflict over dairy policy and cooperative strategies will likely continue. The structural shift in the dairy industry will create winners and losers among traditional dairy farms, rural communities, and environmental integrity. Large dairy farms can easily adopt new technological advances and will continue to produce milk at the lowest possible cost. However, many small dairies will be crowded out. Economic activity will rise in some rural communities and fall in others as the industry concentrates in regional pockets. As dairy concentration progresses, increased dairy waste in a smaller area becomes an increasing environmental concern. Thus, public policy has an important role to play in balancing the costs of a changing dairy industry with the benefits to society at large from a more economically efficient and environmentally sound industry.

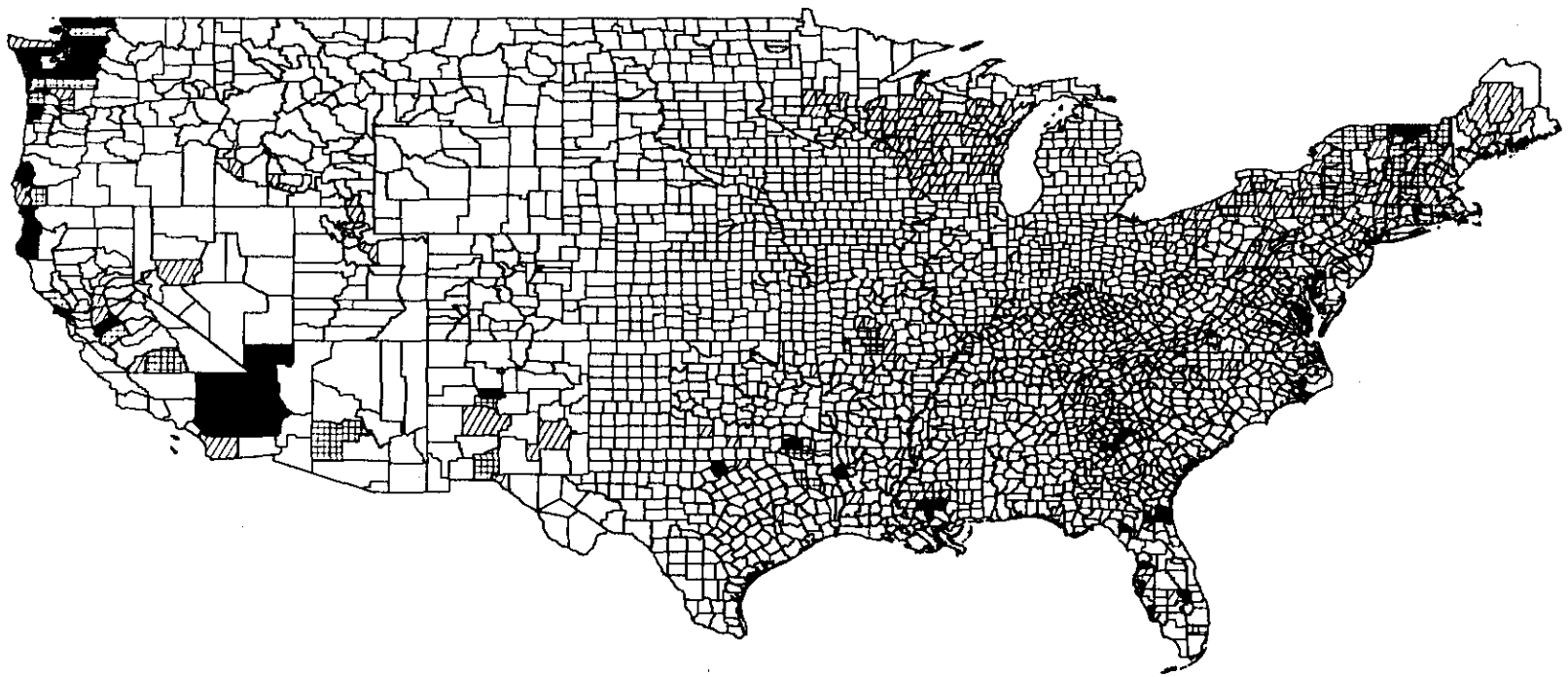
APPENDIX A.
A COUNTY-LEVEL ANALYSIS OF DAIRY WASTE PRODUCTION

There are several methods to determine pollution potential from wastes generated at the concentrated feedlot operations. One such method is to identify where manure nutrient production exceeds crop nutrient assimilation. This method will identify counties that are more likely to have water quality impairments from excess recoverable nutrients from fresh manure even though there is no direct discharge of wastes into the water source. This method assumes that the manure produced locally will be spread on the fields in that locality since it is prohibitively expensive to transport manure from surplus areas to deficit areas. Therefore a local surplus of manure nutrients is a reasonable measure of the likelihood that those excess nutrients will be a source of pollution of surface and groundwater.

A county-level analysis of areas that are likely to have excess total Kjeldahl nitrogen (TKN) and total phosphorus (TP) recoverable from fresh dairy manure is reported here. The excess calculations are based on certain threshold crop requirements of nutrients per acre of harvested crop land. Using county-level data on cow numbers published in Agricultural Census and the standard engineering coefficients of fresh manure and recoverable TKN and TP from the manure (ASAE Standards 1993) estimates of total annual manure nutrient were derived. As per ASAE standards a typical dairy cow weighing 1408 pounds produces 20 tons of manure per year containing 231 pounds of recoverable TKN and 48.4 pounds of TP. Total recoverable nutrients from fresh dairy manure produced in a given county is divided by the total harvested land in that county to estimate nutrients from fresh manure available per acre of crop land. However, it should be noted that these estimates do not account for factors such as manure nutrient management practices, spatial and weather characteristics including hydrology and topography, crop specific nutrient needs and that supplied by commercial fertilizers, and nutrients from other livestock manure.

By assuming arbitrary threshold crop requirements of N and P (for example 0 to 30, 30 to 60, 60 to 90, and more than 90 pounds per acre) the number of counties that fell in each of those thresholds were identified (Table A.1). A list of counties where TP from dairy manure exceeded 30

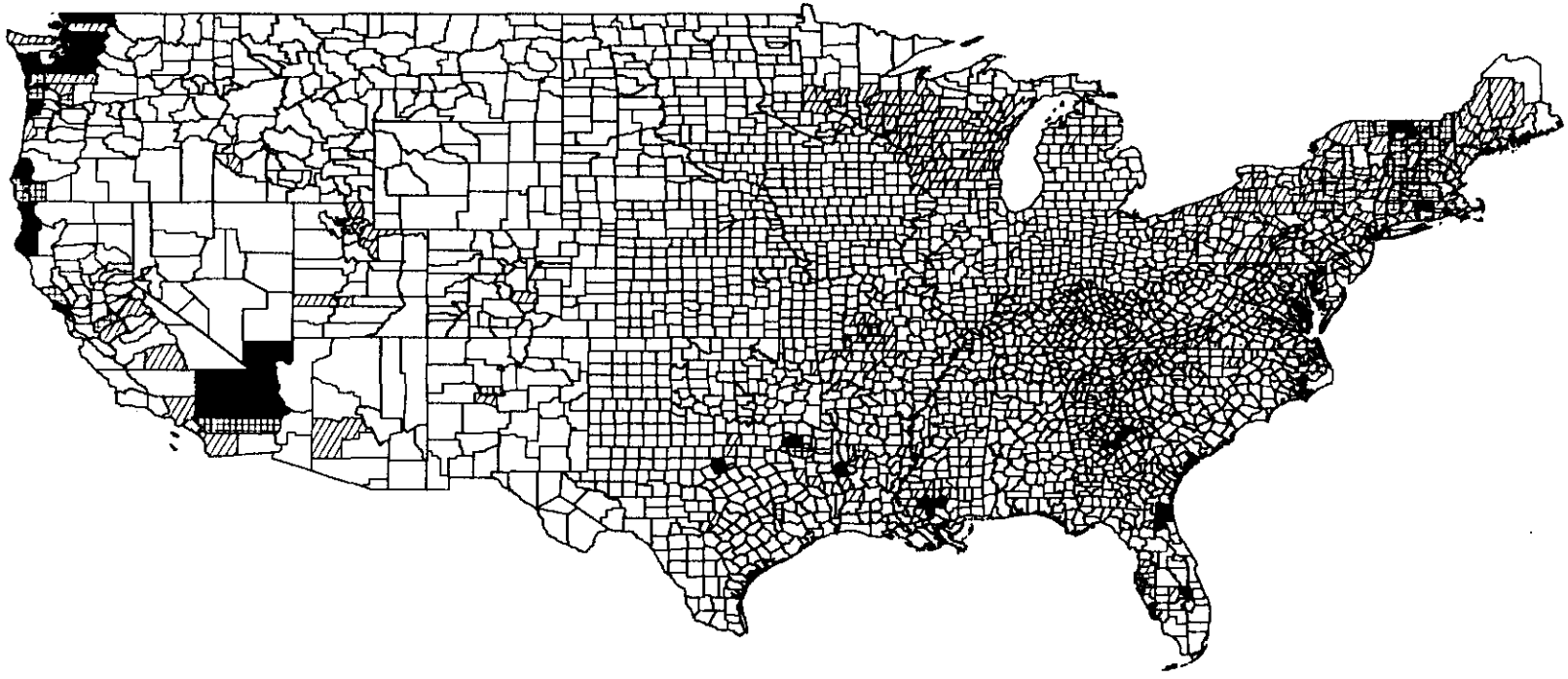
lbs per acre of harvested crop land and a list of counties that had manure produced TKN in excess of 90 lbs per acre were identified (Tables A.2 and A.3). Figures A.1. and A.2. are county-level maps of the United States showing the manure produced TKN per acre of harvested crop land as per 1987 and 1978 agricultural census estimates, respectively. Comparing 1978 and 1987 it could be noticed that New Mexico is likely to experience potential threat from excess dairy manure nutrients. Incidentally, New Mexico is currently the fastest-growing dairy state in the nation.



TKN 15 45 75 105

(Midpoint of TKN in lbs/ac)

Figure A.1. Recoverable total Kjeldahl nitrogen in dairy manure per acre of harvested land, 1987



TKN 15 45 75 105

(Midpoint of TKN in lbs/ac)

Figure A.2. Recoverable total Kjeldahl nitrogen in dairy manure per acre of harvested land, 1978

Table A.1. Distribution of counties based on recoverable total Kjeldahl nitrogen and phosphorous from dairy manure

	TKN		Phosphorus	
Pounds per Acre	Number	Percent	Number	Percent
0 - <30	2,553	87.0	2,912	99.3
30 - <60	270	9.2	15	0.5
60 - <90	70	2.4	4	0.1
>90	41	1.4	3	0.1

Table A.2. Counties with total phosphorous from dairy manure exceeding 30 pounds per acre of harvested cropland

State	County	Harvested in 1987	Total Phosphorous	Manure
		acres	pounds per acre	tons per acre
California	15	2,934	49.738	20.6583
	23	13,512	62.685	27.2818
	41	4,123	181.652	75.4484
	71	39,642	203.102	84.3575
Florida	3	1,942	31.585	15.6106
	31	4,239	54.463	22.6208
	67	7,964	59.970	24.9082
	89	4,347	56.236	23.3575
	93	32,761	65.911	27.3758
Georgia	237	7,407	63.833	26.5127
Louisiana	91	10,671	31.358	13.0243
	105	31,763	41.939	17.4190
Nevada	3	5,924	52.517	24.8128
New Mexico	1	6,896	32.882	13.6575
Oregon	57	4,783	223.472	92.8181
Texas	143	57,110	38.480	15.9823
	223	68,937	46.046	19.1248
Washington	33	12,273	68.946	28.6364
	53	14,320	42.148	17.5058
	61	30,185	36.781	15.2767
	67	9,545	36.096	14.9923
	73	64,984	41.408	17.1985

Table A.3. Counties with total Kjeldahl nitrogen from dairy manure exeeding 90 pounds per acre of harvested cropland

State	County	Harvested in 1987	Total Phosphorous	Manure
		acres	pounds per acre	tons per acre
California	15	2,934	238.03	20.6583
	23	13,512	314.35	27.2818
	41	4,123	869.35	75.4484
	65	217,994	118.93	10.3219
	71	39,642	972.00	84.3575
	99	288,899	90.07	7.8173
Connecticut	13	16,003	97.83	8.4902
Florida	3	1,942	179.87	15.6106
	31	4,239	260.65	22.6208
	53	7,969	103.15	8.9521
	67	7,964	287.00	24.9082
	89	4,347	269.13	23.3575
	93	32,761	315.44	27.3758
Georgia	133	9,902	97.79	8.4868
	169	6,123	93.57	8.1207
	207	5,574	95.56	8.2933
	237	7,407	305.49	26.5127
	265	1,766	126.36	10.9665
Louisiana	31	20,759	95.02	8.2464
	91	10,671	150.07	13.0243
	105	31,763	200.71	17.4190
	117	29,001	142.24	12.3445
Nevada	3	5,924	251.34	21.8128
New Mexico	1	6,896	157.37	13.6575
N. Carolina	5	15,076	100.11	8.6884
Oregon	11	13,780	95.47	8.2853
	57	4,783	1,069.49	92.8181
Texas	143	57,110	184.15	15.9823
	159	15,871	121.73	10.5646
	223	68,937	220.36	19.1248
Vermont	11	78,056	125.12	10.8591
	15	14,418	105.53	9.1588
	19	56,462	113.33	9.8354
Washington	27	13,931	94.80	8.2272
	31	1,709	95.09	8.2523
	33	12,273	329.96	28.6364
	53	14,320	201.71	17.5058
	61	30,185	176.02	15.2767
	67	9,545	172.75	14.9923
	69	3,762	111.62	9.6872
	73	64,984	198.17	17.1985

ENDNOTES

1. The MDP compensated dairy farmers who contracted to restrict their output by 5 to 30 percent of their historical base by paying them $10 per hundredweight (cwt) for the contracted reduction. The DTP required that producers whose bids were accepted sell or export all of their milk cows and cease production for the ensuing five years. These producers received a payment from the government in addition to sales proceeds.

2. The null hypothesis that the listed variables Granger-caused yield or herd size is rejected if the F-value from the Granger-causality test is greater than the critical value. Rejection of null hypothesis implies acceptance of alternative hypothesis.

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