

**Table I-2. Shifts in percent of US milk production--percent of US market share**

	<b>1998</b>	<b>1993</b>	<b>1991</b>	<b>1987</b>	<b>1984</b>	<b>1973</b>	<b>1960</b>
California	17.5	15.2	14.5	12.5	11.3	8.7	6.6
Wisconsin	14.5	15.2	16.2	17.4	17.4	16.3	14.4
New York	7.5	7.6	7.5	8.0	8.4	8.5	8.4
Pennsylvania	6.9	6.8	6.8	7.1	7.0	5.8	5.6
Minnesota	5.9	6.4	6.6	7.3	7.6	8.0	8.3
Idaho	3.7	2.1	2.0	1.7	1.6	1.4	1.3
Texas	3.6	3.9	3.6	3.0	2.8	2.8	2.4
Michigan	3.4	3.6	3.5	3.7	3.9	4.1	4.2
Washington	3.4	3.3	3.0	2.6	2.6	2.0	1.7
New Mexico	2.8	1.8	1.3	.7	.7	3	--
Ohio	2.8	3.1	3.2	3.4	3.4	3.8	4.2
Iowa	2.4	2.7	2.8	2.5	2.8	3.5	4.8
Arizona	1.7	1.2	1.2	1.0	.9	.6	--
Vermont	1.7	1.7	1.6	1.7	1.6	1.7	1.6
Florida	1.5	1.7	1.7	1.6	1.4	1.6	1.1
Missouri	1.5	1.9	1.9	2.0	2.0	2.6	3.0
Indiana	1.4	1.5	1.5	1.6	1.7	2.0	--
Illinois	1.3	1.7	1.9	1.9	1.9	2.4	3.4
Virginia	1.2	1.3	1.4	2.6	1.5	1.5	1.6
Colorado	1.1	1.0	.9	.8	.7	.7	--
Kentucky	1.1	1.4	1.5	1.6	1.6	2.1	2.6
Kansas	1.0	0.7	0.8	0.9	0.9	1.3	1.5
Oregon	1.0	1.1	1.1	1.0	1.0	.9	--

Sources: USDA Economic Research Service, Dairy Situation, March 1985-92. USDA Agricultural Marketing Service, Dairy Market News, Vol. 55, Rep. 10, 1988. USDA Economic Research Service, Dairy Outlook, February 23, 1988. Adapted from: USDA, NASS, <http://usda.mannlib.cornell.edu/re...ssr/dairy/pmp-bb/1999/mkpr0299.txt>

The greatest gains in market share have come in the Western states of California, Washington, Arizona, New Mexico, and Idaho. California has increased its market share by a factor of more than 2.5 since 1960 and is still growing. Pennsylvania, Michigan, and Vermont are the exceptions in the Northeast and Midwestern regions in that they have tended to hold their market share. States losing market share have been in the more traditional dairy areas-Wisconsin, Minnesota, Iowa, Illinois, Ohio, New York, Missouri, and Kentucky. Traditional dairy production areas tend to have smaller herd sizes and more diversified operations that grow a major portion of the feed supply that is marketed as milk.<sup>15</sup> Table I-3 shows how dairy herd size is linked to states and regions.

**Table I-3.  
Herd size profile percent inventory by size groups for selected states – 1998**

	1-29	30-49	50-99	100-199	200-499	500+	
Percent of total cows							
California	--	--	--	3	18	78	
Wisconsin	5	21	43	18	10	3	
New York	3	11	34	26	15	12	
Pennsylvania	5	25	37	22	10	2	
Minnesota	6	22	40	16	12	4	
Michigan	5	11	25	32	18	10	
Idaho	1	2	6	12	19	61	
Washington	--	1	4	16	32	47	
New Mexico	--	--	--	1	3	96	

Source: Jacobson, Larry D., et al., *Generic Environmental Impact Statement on Animal Agriculture*, University of Minnesota, College of Agriculture, Food, and Environmental Sciences, <http://www.mnplan.state.mn.us/eqb/scoping.html>, September, 1999, p. D/E-24.

Consolidation has occurred at the same time that productivity per cow has undergone dramatic increases. Productivity per cow increased three fold between 1945 and 1998, producing 17192 lbs. milk per cow annually nationally in 1998. Washington ranks number one in productivity at 21,476 lbs. milk per cow annually.<sup>16</sup>

### Profits and Efficiency

The most important indicator of dairy farm profits is the cost of waste handling. A Minnesota study found that the cost of compliance with certain EPA regulations affects moderate size dairies more adversely than large size dairies. Large scale dairies can more easily amortize the extra capital investment costs involved with EPA compliance. This suggests that moderate size dairies faced with needing to make investments to meet the EPA standards may choose to expand the scope of their operations, if financially able.<sup>17</sup>

A 1994, University of Minnesota study explored three alternative dairy production systems:

- Purchasing all feed.
- Purchasing grain and raising the additional forage.
- Raising all forages and grains to feed the herd.

This analysis was based on a new start-up dairy with the land and field machinery investment determined by the cropping plan. The systems were analyzed over a range of herd sizes from 138 to 828 cows. The dairy facilities, parlor, manure system, feed storage and housing were designed to meet herd sizes. Summary results of this study are shown in Table I-4.<sup>18</sup>

**Table I-4. Economic performance comparison of three dairy farming systems.**

	Herd size (stalls/cows)					
	100/138	200/276	300/414	400/552	500/690	600/828
<b>Total assets, \$/cow</b>						
Purchase all	3,361	3,152	2,997	2,883	2,845	2,859
Raise forages only	5,393	4,831	4,590	4,447	4,402	4,410
Raise forages & grains	6,594	5,863	5,603	5,391	5,334	5,300
<b>Return on assets, %</b>						
Purchase all	2.5	9.9	12.8	15.6	16.8	17.5
Raise forages only	5.8	11.5	14.2	16.1	16.8	17.2
Raise forages & grains	4.7	10.0	12.4	14.3	15.2	15.5

Source: University of Minnesota, 1994.

This study of a new, start-up dairies suggests some key points:

The dairy industry is capital intensive and there are substantial capital efficiencies gained up to 300 to 400 cows for all three systems. Gains are still realized beyond 400 cows but at a much slower pace. Capital efficiencies are largely due to dilution of two large fixed cost items: the milking center and waste management systems because these costs are not increased greatly by increasing cow numbers.<sup>19</sup>

However, these two costs can have very different impacts on both efficiency and profit calculations. Because the design and cost of milking centers are strictly determined by health regulations, and because much of the nation's milk supply is handled as interstate commerce, a fairly uniform national input determines costs. As a result, there is little a dairy can do to avoid or reduce costs in this category. On the other hand, waste management is generally regulated by county or state rules, and national regulations only come into play when significant pollution of federal waterways or some similar activity occurs. Thus, waste management is an area where significant, profit-increasing shortcuts can be taken, and if such shortcuts are not allowed in a specific state, the absence of federal regulation allows a potential dairy farmer to shop for a state where regulations are loose and enforcement is lax.

If the dairy is a new, start-up operation, cropping machinery and the land base required to feed the herd may add to the capital requirements. Capital investment requirements are reduced by 15 to 20% for the option of raising forages and buying grains compared to raising all the forages and grains. The capital investment is further reduced by 40-45% for purchasing all feed.<sup>20</sup> However, if the dairy is an existing operation where the land and machinery is already owned by the farmer, costs can be reduced considerably by using forage grown on the farm. A comparison of eight grazing dairy herds with eight confined dairy herds in Wisconsin showed that grazing farmers saved an average of \$24 per cow in out-of-pocket costs, and had a cash return of \$.46 more per hundred weight of milk.<sup>21</sup> Further, Pennsylvania State University studies show that grazing can save a total of \$150 per cow annually over conventional confinement dairies, with most of these savings coming in feed costs, labor costs, improved animal health, and reduced culling.<sup>22</sup>

Another recent study conducted at the University of Minnesota North Central Research and Outreach Center compared confinement and intensive rotational grazing for lactating dairy cows over two years. They found that cows in confinement produced 5 to 8% more milk than the grazing cows, but total production costs were reduced by 30% for grazing cows. While milk production was very sensitive to pasture quality changes, net return to grazing averaged \$64.05/cow over confinement in 1991 and \$88.66/cow over confinement in 1992.<sup>23</sup>

The concept of net return/cow or per acre rather than milk production should be the key emphasis of all dairy farms. Managed seasonal grazing allows design of calving patterns to take full advantage of available pasture, the number of cows milking during the winter months is either reduced to a minimum or completely stopped, winter feed storage needs are reduced, and more quality time is provided for the farm family. In addition, the refinement of pasture systems for replacement heifers allows for further reduction in overhead costs to the dairy herd and more optimal heifer growth to first calving.<sup>24</sup>

### **Literature on dairy herd size and efficiency:**

There is no support in the agricultural economics literature for large increases in efficiency as the size of dairy herds grows beyond 200-300. And there is no support for any claims of efficiency for dairy sizes of the kind found in the new, large dairy CAFOs where thousands of animals swamp the land's ability to naturally process the waste. In fact, all of the research conducted thus far on efficiency has been done on herd sizes that are so small that the waste generated by the herd should be easily manageable on a dairy farm of normal size. For example:

In 1999 Richards and Jeffrey found that the average Alberta dairy is highly efficient compared to the best farmers in the industry. Neither investment in human capital or feed quality were important in determining dairy efficiency. The maximum efficient herd size was about 70 cows.<sup>25</sup>

In 1989, Kumbhakar, Biswas, and Bailey found that for dairies of up to 160 cows some economies of size may exist. Large farms (of about 160 cows) are technically more efficient.<sup>26</sup>

Tauer and Belbase working with data on farms of 20 to 275 cows, found that while more cows made a dairy more efficient, they could only explain less than 10 percent of what contributed to successful dairy operations.<sup>27</sup>

In 1996, Ahmad and Bravo-Ureta studied 96 Vermont dairy farms with between 20 and 220 cows. They showed a significant negative relationship between herd size and technical efficiency; i.e., as herd size increased, efficiency decreased.. This finding was consistent with prior work by Bravo-Ureta (1986) and Byrnes et al. (1987) but conflicted with the results of Kumbhakar et al. above.<sup>28</sup>

In 1989, Bailey et al., looked at Ecuadorian dairy farms of from 11 to 130 cows. They found that efficiency increased with farm size, but that capital was a more important factor in efficiency increases.<sup>29</sup>

In 1990, Weersink, Turvey, and Godah found that for dairy farms in Ontario with herd sizes of 15 to greater than 50, efficiency slightly increased with herd size but farms of any size could be efficient.<sup>30</sup>

In 1986, Bravo-Ureta found statistically significant evidence that there was no relationships between dairy farm size and technical efficiency.<sup>31</sup>

Bravo-Ureta and Rieger, in a 1990 study, found that for dairy farms in New York and New England there was a weak relationship between dairy farm size and efficiency.<sup>32</sup>

Tauer found in 1993 that farms with an average of 108 cows were subject to some increasing returns to scale although milking stanchions were not more efficient than stalls and multiple daily milking was also not more efficient.<sup>33</sup>

In sum, the literature shows that there may be some small increases in efficiency when dairy farms expand from twenty to 250. This is logical since herd sizes in this range are small enough that

conventional dairies would already have enough land to recycle the dairy waste from the increased herd size. However, when dairy herds grow to the size of those at the large dairy CAFOs, diminishing returns occur as the costs of responsible waste management rises. For example, when 1996 Minnesota Farm Business Management records were summarized by high and low profit groups within 6 herd size classes, results suggest production cost per 100 pounds of milk to be similar for the high profit farms within all size categories except the very smallest herd size group. The margin of difference between the low and high profit herd within the size groups diminished as herd sizes increased and the cost structure appears to change with different size herds.<sup>34</sup>

### **Profitability in the Dairy Industry**

As the previous section shows, dairy size is not inherently indicative of efficiency. Neither is it a good indicator of profitability. USDA researchers compared differences in the traditional milk producing states (MN, MI, WI, NY, VT, PA, NY, VT) with non-traditional milk producing states (FL, CA, WA, TX, AZ). They found significant differences in the resource base, and the structure of profitability and management practices between the traditional (68 cows) and non-traditional (370 cows) dairies. The factor found contributing most to net farm income regardless of location was size of the operation, but size was irrelevant in explaining per unit returns from dairy. In other words, size causes increases in milk production and income, but on a per-cow basis it has no effect on profit levels.

High productivity and low debt to asset ratios were strongly related to profitability. The importance of management ability to the profitability of the farm business is also noted in a five-state survey of the northeastern and north central region of the U.S. and Canada which found that well-managed farms are able to compete in per-unit profitability with farms many times larger. This is consistent with overall conclusion by Hallam of an “L”-shaped cost curve which becomes flat at fairly low farm sizes—indicating that only expansions in size from the smallest dairies contributes to per unit profit and to efficiency.

El-Osta found that the factors contributing to higher levels of profitability in traditional dairies were low investment costs in land and equipment (which is likely to be the case in older dairies that already own their land and equipment), control of purchased feed cost, age of the operator, use of automatic takeoffs and artificial insemination, and level of adoption of capital- and management-intensive technologies (record keeping combined with parlors).

Factors in non-traditional dairies that also contribute to profitability included lower per cow expenditure for forage production, purchased feed, hired labor, and per cow investment. Per unit returns for dairies with advanced, capital intensive milking parlors rather than traditional parlors were lower—showing that investment in this kind of technology did not pay off. The study shows that the incentives for non-traditional dairies to continue expansion come from production and marketing economies, management expertise, tax incentives, specialization, labor saving equipment, timeliness of getting things done, non-farm investment, and farm consolidation.<sup>35</sup> Note that increased efficiency and increased per-unit profit are not among these incentives.

### III. The Economic Effect of Dairy CAFO Production On Regional Economies

#### What the literature says about the economic effect of dairies

In 1999 the University of Minnesota Extension Service published a descriptive report that traces the linkages between dairy farms, dairy processors, and other sectors in the state's economy. It found that the 22,037 persons employed on dairy farms and processing plants support another 22,222 persons in support industries and another 9,437 in consumer sectors. In total, the dairy industry supports 53,696 jobs in the Minnesota economy. The value-added income earned by dairy producers and processors was \$1.02 billion and supported another \$1.39 billion in support and consumer industries.<sup>36</sup> Thus, both the employment and income multipliers were about 2.4.

While this study demonstrates the importance of the existing dairy industry, it cannot be used to estimate the impact of expansion or contraction of the size of the dairy industry. Estimates of the impacts of expansions or contractions in the dairy industry would need to examine potential offsetting effects in other industries—in other words, if the workers who were laid off in the dairy industry were quickly hired elsewhere, there would be little economic effect. Thus to examine the net effects would require explicit definition of the offsetting effects in other sectors.<sup>37</sup>

Two other regional economic impact studies for North Dakota and Idaho have also been completed. A 1993 study examined the impacts on North Dakota of twenty new 500-cow herds to the state's economy. Using regional input-output analysis, this study estimated a total value-added income increase of \$18 million or about \$900,000 per 500-cow herd. The study also claimed that an estimated 580 full-time secondary jobs would be created, as well as 140 direct jobs. These estimates are valid only if the following two assumptions are true:

First, new jobs must go to in-migrants or to new entrants to the labor force. If the new jobs go to existing workers who are commuting to jobs outside the region then the new income to the region would be lower than estimated.

Second, if the jobs go to workers who already work within the region and in-migrants do not come in to take their jobs, this development could drive up wages in the region. Then the number of total jobs would not increase as rapidly as shown in the estimate.<sup>38</sup>

Another 1993 study that examined the impacts of dairy production in Idaho showed that Idaho had 24 percent more dairy cows in 1991 than in 1970. Using an Idaho regional input-output model, the authors estimate that milk production and processing accounted for 6 percent of the state's gross income in 1989, measured in value-added terms. However, due to differences in the local economic structure the multiplier effects varied considerably from region to region and this must be regarded as only a descriptive study that has no implications about the potential impacts of changes in the size of dairy herds.<sup>39</sup>

All of these studies addressed the general importance of the dairy industry. Yet, none of them satisfactorily addressed the net changes in a region's economy due to changes in the dairy industry. The North Dakota study probably comes the closest to doing this but both the estimates and the offsetting effects would need to be localized to guide zoning policies. Since the nature of the impacts depends on the structure of the local economy, both the size and the distribution of the impacts will vary with the region being studied. This was demonstrated in the Idaho study that reported differing multipliers for the same processing sectors in different regions. In areas of very high unemployment and little rural

residential development there will be minor off-setting effects. However, if labor markets are tight and the land is likely to be used for high valued residential developments, the offsetting effects will be high<sup>40</sup> And finally, none of these studies specifically addressed the regional impact of the purchasing practices, hiring practices, and externalities (the costs of odor, water pollution, etc. that shifted to the residents around the dairy) associated with large dairy CAFOs.

### *How large Dairy CAFOs are Likely to Affect the Regional Economy*

There is a significant difference between economic growth and economic development. Economic growth concentrates on short-term changes in jobs or prices while economic development has the objective of creating a diversified economy that is capable of providing jobs, economic stability and economic growth for the citizens of a region over the long term. As a result, most communities have begun to focus on economic development and in regions where agriculture has been the mainstay of the economy and most rural regions are now trying to diversify to avoid the economic problems that have characterized the agriculture industry over the last twenty years.

Large dairy CAFOs with concentrated masses of animals neither diversify a rural regional economy nor improve the long term economic health of a region. Instead, the few likely economic benefits come as short term gains to developers and investors and do not contribute to the long-term economic development of the region. In addition, the economic characteristics of large dairy CAFOs are fundamentally incompatible with regional economic development. Regional economic development proceeds on the premise that the wages paid and purchases made by a company are transferred to other individuals or companies in the region. The multiplier effect of these payments further assumes that they are again spent within the confines of the region, that they do not “leak” into other areas of the state or nation, and that they are not offset by other economic activity in the region. However dairy CAFOs are structured so that they cannot aid regional economic development for the following reasons:

#### (1) Constraints on Regional Economic Development Due To Employment

As a capital intensive company, a dairy CAFO is designed to minimize the number of workers and hence, minimize the economic impact on the region. For the employment multiplier to operate at the levels specified in the Department of Commerce RIMS II model, all employees must both live and work in the region. Ideally, these employees would buy a hamburger at a local restaurant that buys milk and meat from a local producer, who buys feed from a local farmer, etc., etc. However, given the short commute from most rural regions where dairies are located to larger, urban areas, it is likely that most workers will live well outside the region. If workers live outside the region, the worker’s wages are transported out of the region each month and they are spent in the urban economies and the local employment multiplier will be further depressed.

Some dairy jobs may be filled with local people. To the extent that these dairy workers live in the local region a portion of their wages may be spent in the local economy. However, the proximity of shopping in urban areas is again likely to lessen the impact of these expenditures.

Finally, the size of the employment multiplier further depends on the amount of purchases that the proposed dairy itself makes in the region. Research shows that large scale agricultural operations are more likely to purchase their inputs from a great distance away, bypassing local providers in the process.<sup>41</sup> A 1994 study by the University of Minnesota Extension Service found that the percentage of local farm expenditures made by livestock farms fell sharply as size increased. Farms with a gross

income of \$100,000 made nearly 95% of their expenditures locally while farms with gross incomes in excess of \$900,000 spent less than 20% locally.<sup>42</sup>

Confined animal production can occasionally benefit local grain and forage sellers, but only when it consumes all the grain or forage produced in the county. If the county has to export even one bushel of grain or one bale of hay, all the grain and hay in the county will have to be priced at a lower level that will enable the grain to compete in the export market.<sup>43</sup>

## (2) Constraints on Regional Economic Development Due To Taxes

Federal, state and local taxes are levied on taxable amounts calculated on federal returns. The numerous tax write-offs that are possible because large dairy CAFOs are sometimes treated as industries and, at other times, treated as farms, significantly decrease the amounts of taxes paid locally. At the same time the operations of the dairy CAFO create significant social, health and traffic costs that the local government must finance. The local government, in turn, must rely on increased taxes to pay these CAFO-induced costs--and this can decrease other economic activity in the region.

For example, additional costs associated with hosting a CAFO include increased health costs, schooling costs, traffic, accidents, and repairs. One Iowa community estimated that its gravel costs alone increased by about 40% (about \$20,000 per year) due to truck traffic to hog CAFOs with 45,000 finishing hogs. Annual estimated costs of a 20,000 head feedlot on local roadways were \$6447 per mile due to truck traffic.<sup>44</sup> Colorado counties that have experienced increases in livestock operations have also reported increases in the costs of roads, but specific dollar values are not available.<sup>45</sup> In addition, an Iowa study found that while some agricultural land values increased due to an increased demand for "spreadable acreage," total assessed property value, including residential, fell in proximity to CAFO operations.<sup>46</sup>

## (3) Constraints on Regional Economic Development Due To Vertical Integration

Vertical integration requires purchases from and sales to other members of the vertically integrated company, not from local producers and suppliers. The same method of doing business holds true for the large dairy cooperatives. Thus, vertically integrated companies and dairy cooperatives stimulate regional economies only to the extent that all elements of the production and processing cycles are located in the region. Historically, this factor has severely limited the economic impact of dairy CAFOs on the regions in which they are situated.

## (4) Constraints on Regional Economic Development Due To Cost Shifting

The previous three sections have described the reasons inherent in the structure of dairy CAFOs that most of the money from a CAFO will either be directly spent outside the region or it will quickly migrate there. However, through cost shifting the CAFO will leave the costs of its odor, health risks, surface water pollution, ground water pollution and in the long run, its abandoned lagoons and facilities for the region to deal with. This directly effects both long and short run economic development.

Put bluntly, every company has many choices of location and active recruitment is practiced by most regions. Quality of life is a major factor in decisions to locate in a region, and most companies would never consider locating in an area where a CAFO is operating. In addition, CAFOs can adversely impact the value of neighboring property in the region.

For example, in the Saline County, Missouri, study, researchers at the University of Missouri collected data on 99 rural land and non-family real estate transactions of more than one acre. There are

35 CAFOs in Saline County; 32 are primarily swine, two are beef, and one is poultry. 39 of these properties included a house. The researchers found that proximity to a CAFO does have an impact on property values of nearby property if the property has a house on it.. Based on the averages of collected data, loss of land values within 3 miles of a CAFO would be approximately \$2.68 million or approximately \$112 per acre.<sup>47</sup>

Palmquist et al., in a 1995 study in North Carolina, found that neighboring property values were affected by large hog operations based on two factors: the existing hog density in the area and the distance from the facility. The maximum predicted decrease in real estate value of 7.1 percent occurred for houses within one-half mile of a new facility in a low hog farm density area. A 1997 update of this study found that home values decreased by \$.43 for every additional hog in a five mile radius of the house. For example, there was a decrease of 4.75% (about \$3000) of the value of residential property within 1/2 mile of a 2,400 head finishing operation where the mean housing price was \$60,800.<sup>48</sup> A 1996 study by Padgett and Johnson found much larger decreases in home value than those forecast by Palmquist. In Iowa, CAFOs decreased the value of homes in a half-mile radius by 40%, within 1 mile by 30%, 1.5 miles by 20% and 2 miles by 10%.<sup>49</sup>

### *Conclusions*

A large dairy cannot diversify a rural regional economy already dependent on agriculture. Instead, it damages the ability of the region to attract diversified economic growth and it is likely to cause property values around the dairy site to decrease. In the long run, the legacy of air and ground water pollution that often accompanies large dairies hinders long-term economic development and makes the region a magnet for other dirty operations who are looking for contaminated, brown field sites that can be used for further contaminating operations.

When rural regions are faced with the prospect of such operations they should evaluate the proposed land use based on the following questions:

1. Does the proposed use make sense in light of budgetary, political, environmental and health considerations given the likely health and environmental effects of the proposed dairy?
2. Does the proposed use make sense in terms of the region's ability to host such a facility given likely groundwater supply and contamination issues?
3. Have all costs and all benefits been fairly considered? In particular, have the potential health costs of air and water pollution, the costs of site remediation, and the potential costs of waste treatment all been considered?
4. What are the short run and long run economic impacts? In the short run, construction employment usually goes to outside sources in most rural communities. In the long run, there will be an increase in some jobs, but where will the workers live, what will the level of pay be, where will the money be spent, and which jobs will not come to the region because of the proposed dairy?
5. Who benefits from this land use? Who does not benefit? Is there any vehicle in place to reimburse residents whose quality of life or health is degraded by the proposed facility?
6. Does the proposed land use create an environment that helps the region maintain a stable, diversified economic base?

## IV. Factors that Shift the Costs of Large Dairy CAFOs To Local Residents

### *Ground Water Pollution*

Large, concentrated animal operations such as dairies require massive amounts of water. This can result in substantial draw downs of aquifers in areas where aquifer content is limited and declining. And this shifts the real cost of the dairy's water to other water users in the area by increasing pumping and well drilling/deepening costs. About 5 to 10 gallons of fresh water per day for each cow milked are used in a milking center where flushing of wastes is not practiced. However, where manure flush cleaning and automatic cow washing are used, water use can be 150 gal/d/cow or more.<sup>50</sup>

Aside from high water usage, the main water-related environmental problem from dairy production is the same as that from other livestock operations: animal waste discharge into waterways or aquifers. Runoff from dairy operations flows from pastures and, in more concentrated form, from barns and manure piles. These discharges overload natural waterways with nitrogen and phosphorous compounds, collectively termed nutrients. Excess nutrient loads encourage algae growth, reduce dissolved oxygen, and impair the habitat for fish and other species. In some areas, the percolation of dissolved minerals into groundwater contributes to the salinity of water supplies.<sup>51</sup>

In addition, nitrogen and other contaminants can flow into underlying aquifers, making the water unusable for drinking--even for animals. For example, in California's Central Valley, dairy farmers discovered their cows were aborting calves after drinking water from wells contaminated with nitrates--nitrates that leached into the groundwater from the manure of other dairy cattle. When wells are contaminated with nitrates, human health problems can also result. For example, the LaGrange County Health Department in Indiana identified six miscarriages among women whose wells had been contaminated by nitrates. High concentrations of nitrates cause 'blue baby syndrome'--a disease that damages the red blood cell's ability to carry oxygen.<sup>52</sup>

In addition to these problems, the runoff from cattle manure also carries pathogens that can cause disease and death. For example, the recent case at a New York fair where E. coli 0157:H7 killed an elderly man and a three-year-old girl, and sickened more than 600 others, was blamed on well water that may have been contaminated by nearby dairy cow barns.<sup>53</sup>

A more common pathogen in dairy manure is cryptosporidium. In 1993 an outbreak of cryptosporidium in the Milwaukee, Wisconsin drinking water system made 400,000 people sick and led to the deaths of more than 100 people. The suspected cause of this outbreak was runoff from dairy cattle manure.<sup>54</sup> It is interesting to note that at the time of this outbreak, a 500-cow dairy herd was considered to be a large farm and a 1400-cow dairy operation was only proposed in Wisconsin 1998.<sup>55</sup>

## *Air Pollution from Odor and Emissions*

### (1) Gaseous Emissions

Open manure storage facilities can be a very significant source of on-farm odors and volatile gases. They are the most apparent odor source, especially if there are no visual barriers from neighbors or passersby. One method to reduce odors and gaseous emissions from open manure storage units is to place some type of cover on the surface. Further, reasonably low emissions may come from dairy manure storage basins that have a natural crust.<sup>56</sup> However, lagoon covers of any type do nothing to stop gasses and odors generated in barns and confinement buildings, and these are the source of about 60% of all odors from Concentrated Animal Feeding Operations.

#### (a) Hydrogen Sulfide

The Minnesota study reported that an investigation of air quality in six Alberta commercial free-stall dairy barns concluded that the concentrations of hydrogen sulfide (H<sub>2</sub>S) were low (the maximum recorded value was 145 ppb), and the possibility of detecting more than trace concentration of H<sub>2</sub>S was remote where manure was removed from free-stall dairy units with solid passageways. However, significant quantities of hydrogen sulfide can be released during agitation of stored liquid manure. Research has documented peak hydrogen sulfide concentrations near the floor of dairy barns during agitation at 70 ppm.<sup>57</sup>

#### (b) Ammonia

Studies of the air quality in six Alberta commercial free-stall dairy barns also found concentrations of ammonia (NH<sub>3</sub>) present in all six barns and the overall mean values ranged from 7 to 20 ppm. The overall mean NH<sub>3</sub> production rates ranged from 1.7 to 4.4 L/[hour-cow (500 kg cow)].<sup>58</sup> Table I-5 relates ammonia generation to the method of housing dairy cows.

**Table I-5. Influence of housing type on dairy ammonia emissions**

<u>Type</u>	<u>Management</u>	<u>Ammonia</u>	<u>Units</u>
Dairy	Freestall	7-13	g/LU/day
	litter	260-890	mg/500 kg/hr
	cubicles	843-1769	mg/500 kg/hr

Source: Jacobson, Larry D., et al., Generic Environmental Impact Statement on Animal Agriculture, University of Minnesota, College of Agriculture, Food, and Environmental Sciences, <http://www.mnplan.state.mn.us/eqb/scoping.html>, September, 1999, p. H-39.

(c) Methane

Methane emissions are both a global and a local problem. They are a significant cause of global warming and they result any time manure is stored and begins to decompose. As a result, methane generation is dependant on the storage method selected and the ambient temperature at the storage location. Tables I-6 and I-7 demonstrate that three times more methane is generated by dairy cows than by any other farm animal type. Further, the use of liquid slurry or solid manure management both result in much higher methane emissions than pasture/feedlot operations.

**Table I-6. Estimated methane emissions from livestock and poultry waste**

<u>Animal Type</u>	<u>Methane Emissions (kg/year per animal)</u>
Cattle in feedlots	23
Dairy	70
Swine	20
Caged Layer	0.3
Broiler	0.09
Turkey and ducks	0.16

Source: Jacobson, Larry D., et al., Generic Environmental Impact Statement on Animal Agriculture, University of Minnesota, College of Agriculture, Food, and Environmental Sciences, <http://www.mnplan.state.mn.us/eqb/scoping.html>, September, 1999, p. H-41.

**Table I-7. Measured methane emission factors (MCF) for dairy cows**

<u>System Type</u>	<u>MCF estimates</u>	<u>MCF measured at 20°C</u>
Pasture/Feedlot	10	0.3
Liquid slurry	20-90	55.3
Solid	10	45.7

Source: Jacobson, Larry D., et al., Generic Environmental Impact Statement on Animal Agriculture, University of Minnesota, College of Agriculture, Food, and Environmental Sciences, <http://www.mnplan.state.mn.us/eqb/scoping.html>, September, 1999, p. H-41.

(2) Odors

There is evidence that odors from concentrated animal facilities can produce real illnesses in affected populations adjacent to these facilities. A report by the State Health Director of North Carolina notes that exposure to environmental odors results in physiological stresses that may result in a variety of symptoms including headache, nausea, loss of appetite, and emotional disturbance. Odors may exacerbate stress-related illnesses. The symptoms may result from odor annoyance, stress associated with odor exposure, and conditioned responses to odors. The literature also reports that exposure to odors may exacerbate asthma symptoms.<sup>59</sup> The following excerpts of articles address human response to environmental odors:

N. P. Shukia (1991) "In the case of humans, the immediate physiological stresses produced by odors can cause loss of appetite and food rejection, low water consumption, poor respiration, nausea, and even vomiting, and mental perturbations. In extreme cases, offensive odors can lead to deterioration of personal and community well-being, interfere with human relations, deter population growth and lower its socio-economic status."<sup>60</sup>

Dennis Shusterman (1992) "Environmental odor pollution problems generate a significant fraction of the publicly-initiated complaints received by air pollution control districts. Such complaints can trigger a variety of enforcement activities under existing state and local statutes. However, because of the transient timing of exposures, odor sources often elude successful abatement. Furthermore, because of the predominantly subjective nature of associated health complaints, air pollution control authorities may predicate their enforcement activities upon a judgment of the public health impact of the odor source. Noxious environmental odors may trigger symptoms by a variety of physiologic mechanisms, including exacerbation of underlying medical conditions, innate odor aversions, aversive conditioning phenomena, stress-induced illness, and possible phenomenal reactions."<sup>61</sup>

Shim and Williams (1986) "Many patients complain that some odors worsen their asthma. Perfume and cologne are two of the most frequently mentioned offenders. A survey of 60 asthmatic patients revealed a history of respiratory symptoms in 57 on exposure to one or more common odors. Odors are an important cause of worsening of asthma. From a practical standpoint, sensitive asthmatic patients should be advised to eliminate odors from their environment as much as possible."<sup>62</sup>

Susan Knasko (1993) "The effects of intermittent bursts of pleasant, unpleasant, and no experimental odor on human task performance, mood, and perceived health were tested in this study. Odors did not influence any of these measures; however, subjects who had been exposed to the malodors reported retrospectively that they thought the odors had a negative effect on all of these factors."<sup>63</sup>

Pierre Caralini (1994) "With regard to general health complaints, it was found that when exposed to odorant concentrations, some people are annoyed and of these people, only some report general health complaints. Exposure in itself does not directly cause general health complaints. Annoyance is the intervening variable between exposure and general health complaints. A possible explanation for the relation between annoyance by malodor and general health complaints might be found in the personality and attitudes of the exposed individual. Finally, we found confirmation for the appraisal hypothesis, i.e., the extent to which individuals regard malodor as threatening is positively related to odor annoyance."<sup>64</sup>

Shusterman, et. al. (1991) "Retrospective symptom prevalence data, collected from over 2000 adult respondents living near three different hazardous waste sites, were analyzed with respect to both self-reported 'environmental worry' and frequency of perceiving environmental ('particularly petrochemical) odors. Significant positive relationships were observed between the prevalence of several symptoms (headache, nausea, eye, and throat irritation) and both frequency of odor perception and degree of worry. Headaches for example, showed a prevalence odds ratio of 5.0 comparing respondents who reported noticing no such odors and 10.8 comparing those who described themselves as 'very worried' versus 'not worried' about environmental conditions in their neighborhood."<sup>65</sup>

## *Health-Related Problems*

### (1) Respiratory disorders

Clinical and epidemiological studies of confinement farmers in the dairy, swine, and poultry industries have shown an excess of acute and chronic respiratory disorders among workers exposed to high dust levels and various toxic gases. Acute health effects are particularly common. These are

manifested mainly by symptoms of respiratory irritation (cough, phlegm production, and frequent wheezing), upper respiratory and eye irritation, acute decreases in lung function during the work period, and increased rates of upper and lower respiratory infections (Donham et al., 1984b, 1988, 1989; Dosman et al., 1988; Holness et al., 1987; Iversen et al., 1989; Iversen and Pederson, 1990; Iversen and Takai, 1990; Reynolds et al., 1994; Terho, 1990; Vohlonen et al., 1987; Wilhelmson et al., 1989). The rates of allergic disorders (asthma, rhinitis) are increased also among farmers in animal and poultry confinement facilities (Amishima et al., 1995; Donham et al., 1984b; Iversen et al., 1989; Noorhassim et al., 1995; Prior et al., 1996; van Hage-Hamsten et al., 1985; Vogelzang et al., 1997; Wilhelmson et al., 1989).<sup>66</sup>

## (2) Other diseases

Incidents of human disease attributable to contact with livestock waste have been reported. Stanley et al. (1998) isolated *Campylobacter jejuni* from groundwater in the Arnside area of Cambria. Some of the strains isolated were of the same biotype as the ones from a dairy farm situated within the hydrological catchment of the polluted spring indicating that the groundwater was a vehicle for bacterial transmission. In a longitudinal study of four dairy farms, it was suggested that *E. coli* O157:H7 was disseminated from a common source on these farms and that this strain could persist in the herd for up to 2 years (Shere et al., 1998).<sup>67</sup>

Large numbers of viruses are excreted in infected animal feces. In fact, enteroviruses have been found in all animal species that have been extensively studied. These animal viruses can gain entrance to streams, lakes and other bodies of water via land application of animal wastes or by direct contamination from pastures and feedlots. Constant fecal contamination of open water in pastures and washings of pens, closed lots and dairy operations are important in this respect. (Malherbe et al., 1967).<sup>68</sup>

### (a) *Campylobacter*

Berndtson et al. (1996) isolated *Campylobacter* from flies netted in anterooms of barns containing positive broiler flocks in Sweden. Urban and Broce (1998) isolated *Salmonella* and three other kinds of bacteria from 43% of house flies and blow flies netted around dog kennels in Kansas, where meat from a neighboring rendering plant was the main food for the dogs. And recently, Iwasa et al. (1999) isolated the enterotoxigenic *E. coli* O157:H7 from 1.6% of house flies netted directly from cattle manure piles at 1 of 4 dairy farms in Hokkaido, Japan. Collectively, these studies demonstrate that varying percentages of flies netted around animals and their manures can harbor isolatable loads of potentially pathogenic bacteria.<sup>69</sup>

A wide variety of wild and domestic animals also serve as reservoirs of *Campylobacter* that normally colonize their gastrointestinal tract (Angulo, 1997). The foods that have been implicated in outbreaks are milk, poultry and red meat (Varnam and Evans, 1991). A relatively large number of outbreaks are water-borne, because this pathogen has the ability to survive in water in an infectious state (Nachamkin, 1997). From a subset of the NAHMS 1996 national dairy study herds tested using a PCR test, 100% of herds tested had positive cows with an individual milk cow prevalence of 43%.<sup>70</sup>

### (b) *Salmonella*

A variety of animal species are reservoirs of infection, including cattle, swine, and poultry. Information from the NAHMS 1996 national dairy study indicates at least 28% of dairy operations have milk cows shedding *Salmonella* at any point in time (Wells et al., 1998). There is also evidence of

clustering of Salmonella on certain dairy operations.<sup>71</sup>

In Germany, Salmonella was detected in 50% and 36% of samples of biowaste and fresh compost, respectively. The seepage water from these sources was found out to be a reservoir of Salmonella; Salmonella enteritidis survived in seepage water for 42 days at 5 °C (Knop et al., 1996). In lake water, Campylobacter jejuni survived longer than C. coli both at 4 °C and 20 °C (Korhonen et al., 1991). Salmonella were found in the environment of a dairy two years after the occurrence of a clinical outbreak of salmonellosis. Samples of recycled flush water were positive for Salmonella indicating that hardy organisms can become established in the environment of modern free-stall dairies that use recycled water in their manure flush systems (Gay and Hunsaker, 1993).<sup>72</sup>

(c) E. coli

Cattle are considered the primary reservoir of human infection from E. coli O157, though other species including dogs, horses, flies, and birds have cultured positive (Hancock et al., 1998). From the NAHMS 1996 national dairy study, 24% of dairy herds had at least one culture-positive milk cow, with a milk cow prevalence of about 1% (Wells et al., 1998). These estimates are consistent with those from the NAHMS 1995 national feedlot study (63% of feedlots, with higher sampling per feedlot, and 1% of fecal samples). Typical duration of shedding is short.<sup>73</sup>

The source of transmission for a large number of E. coli outbreaks has been confirmed to be cattle asymptotically infected with E. coli O157:H7 (Rajkowski, et al. 1998). The contamination has been clearly identified to occur at the milking parlor in outbreaks associated with dairy products (Morgan, 1993). Direct transmission from cattle to humans has also been documented (Armstrong et al., 1996).<sup>74</sup> Because cattle are a natural reservoir of E. coli O157:H7, more than 30 surveys have been conducted in the U. S., U.K and Europe to determine the prevalence of this pathogen in feces of bovine populations. Herd prevalence between 22% and 100% indicated that E. coli O157:H7 is widespread in both beef and dairy cattle where the prevalence appears to be highly variable within herds (Armstrong et al., 1996; USDA/APHIS, 1997). The median percentage of E. coli positive animals within herds calculated from those studies was 1.7 %, and the range varied from 0 in four cases to 63% in a recent report (Jackson et al., 1998).<sup>75</sup>

(d) Listeria monocytogenes

Very little is known about the ecology of Listeria monocytogenes on dairy operations, though it is considered to be ubiquitous in many environments. Weber found 33% of 138 German cattle shedding in feces (1995). Risk factors among French farms included poor quality of silage (pH > 4.0), inadequate frequency of cleaning the exercise area, poor cow cleanliness, insufficient lighting of milking barns and parlors, and incorrect disinfection of towels between milkings (Sanaa, 1993).<sup>76</sup> Listeria can survive and grow at refrigeration temperatures; milk, cheese and ready-to-eat meats have been implicated in many outbreaks. This is a characteristic that distinguish this bacterium from other foodborne pathogens, even a few contaminant cells can be enough inoculum to reach infectious dose levels (Bell and Kiriakides, 1998).<sup>77</sup>

(e) Mycobacterium paratuberculosis

The NAHMS 1996 national dairy study has estimated at least 22% of dairy herds have at least one Mycobacterium paratuberculosis test-positive cow with a milk cow prevalence of 3.4% (NAHMS, 1997). The prevalence in dairy herds is greater than that found in U.S. beef cow-calf operations. Control of infection is possible, though requires long-term commitment using currently available tests.<sup>78</sup>