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Manure Management inWisconsin: Results of the 1995 Wisconsin Farmer Poll

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A Profile of Manure Management on Wisconsin Livestock Farms

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I. Introduction

Over the past 20 years, a significant amount of state and federal money has been spent researching the impacts of farming activities on water quality in Wisconsin. Manure and nutrient management practices have been identified as critical variables affecting the environmental performance of most farms in the state. To protect surface and groundwater resources, a number of technical and managerial solutions have been designed to minimize nutrient leaching and runoff from barnyards and farm fields. An impressive array of educational programs, financial subsidies, and regulatory incentives has been employed to encourage livestock producers to manage their manure in environmentally responsible ways.

Because of the considerable public investment in this area, it is perhaps surprising that there have been few efforts to systematically analyze the degree to which farmers in Wisconsin are following recommended practices.[1] This report provides a profile of the manure storage and handling practices on a random sample of Wisconsin livestock operations in the spring of 1995. First, the results are presented for livestock farms overall, and adoption patterns on dairy farms are contrasted to those of other kinds of livestock enterprises. Next, data for dairy farms are explored in more detail to look for patterns related to the scale of the operation. The third section outlines the farm and household characteristics of producers who do and do not use various practices. The report concludes with a discussion of what we know and don't know about Wisconsin livestock farmers' adoption of recommended manure management practices, a brief analysis of reasons for the patterns we observed, and a review of the implications of our results for university scientists, Cooperative Extension faculty, state policy makers, and others seeking to improve the effectiveness of manure and nutrient management programs.

II. Background

The deteriorating quality of Wisconsin's ground and surface waters is of growing public concern. Inadequate management of livestock manures and over-application of commercial fertilizers are now considered major sources of nitrate leaching and phosphorus runoff in the state. In Wisconsin, an estimated 40 percent of rivers and streams and over 90 percent of lakes are degraded by non-point source pollution, the primary source of which is considered to be agriculture (Odgers 1992).

The results discussed below suggest that few farmers currently experience problems complying with existing regulations on the storage and handling of manure in Wisconsin. Nevertheless, it is widely perceived that growing public concerns about water and air quality are likely to lead to much tighter rules and regulations on the flows of nitrates and phosphorus from dairy and other livestock operations over the next few years. Currently, the State of Wisconsin's Departments of Agriculture, Trade, and Consumer Protection (DATCP) and of Natural Resources (DNR) are revamping their regulatory approaches and looking for ways to coordinate their efforts to improve water and air quality outcomes. With non-point pollution from agriculture identified as a leading source of contemporary water quality problems in the state, farmers with livestock will almost certainly face pressure to improve their manure management.

The good news is that there appears to be considerable room to reduce non-point pollution by improving management at all stages of production on livestock farms (Powell, 1995; Sturgul and Bundy, 1996). For example, it has become apparent that dairy farmers tend to provide their animals with more nitrogen (N) and phosphorus (P) in their feed than is necessary to sustain their milk production and long-term reproductive performance (Satter and Shiman, 1996). As a result, manure tends to have higher N

and P levels than would occur with better feed nutrient management. The timing and frequency of manure application to cropland also affect the rate at which nutrients are lost into surface and ground waters. Three other strategies to reduce environmental risks are: building improved manure storage structures to allow more leeway in timing applications; avoiding spreading manure on frozen ground, particularly on steep slopes or adjacent to waterways; and physically incorporating manure into the soil shortly after spreading.

The phosphorus and nitrogen contained in manure make it a good fertilizer for cropland. According to Shaw (1994:19), "manure alone, if efficiently collected and distributed, would meet most crop [nutrient] needs in Wisconsin." Thus, when nutrients available from manures and previous legume crops are not accounted for in the calculation of commercial fertilizer application rates, land is likely to be over-fertilized. Nowak et al. (1996) have found that many farmers do not effectively credit their soils for the N and P they are applying through manure spreading and legume rotations, and thus often add more commercial fertilizer than is necessary. Indeed, Nowak and his colleagues found that only one in 35 Wisconsin farmers appears to be crediting manures within 10 percent of University recommendations.[2] The result is increased potential losses of nutrients to the environment and financial losses to the farm enterprise.

While agriculture has been linked to deteriorating water quality overall, it would be misleading to assume that all farms are equally responsible for the problem. It should be obvious that the stocking rate of individual operations, and the feeding, manure handling, and cropping management systems they employ, will all affect the environmental impacts from farming activities. It is less well appreciated that biophysical characteristics of a farm (such as soil type, topography, and proximity to waterways) influence susceptibility to ecological damage, and can vary quite considerably across the state. This suggests that similar practices in different settings may lead to quite different environmental outcomes.

III. PATS Research on Manure Management

In 1995, the Agricultural Technology and Family Farm Institute (ATFFI) at the University of Wisconsin-Madison conducted a mail survey of 1,100 randomly selected Wisconsin farmers.[3] This survey was designed to gather information about the use of various farm technologies and management practices as well as farmers' attitudes toward environmental regulation from a representative sample of Wisconsin farmers. Out of 1,100 farms in the sample, 135 were determined to be no longer farming, and were considered ineligible. A total of 532 usable surveys were returned, and another 433 were either not returned or were otherwise unusable. This produced a response rate of roughly 55 percent of the eligible sample. As outlined below, the respondents appear to be representative of farms in Wisconsin.

The questionnaire included baseline data on the numbers and kinds of livestock, the use of various manure storage structures, and questions about manure spreading practices. It also included data on farm enterprise characteristics such as land ownership, gross farm sales, off-farm work, debt-to-asset ratio, and future plans and expectations. To keep the survey short, it did not include field-specific information about tillage practices, cropping patterns, rates of commercial fertilizer application, soil types, topography, and other biophysical characteristics that influence rates of nutrient loss on individual farms. As a result *we cannot directly infer from our results whether or not a particular farm has a nutrient management problem.* However, a close look at patterns of producer behavior can serve as a springboard for further research on this issue, including a future analysis of a more detailed statewide survey of dairy farmers in the spring of 1997 that will be reported in future publications.

IV. Characteristics of the Sample

Before discussing manure management on typical Wisconsin livestock farms, it is helpful to have a better sense of the farms in our sample. The following section summarizes some of the enterprise and household characteristics of the respondents, compares them to farms that were enumerated in the 1992 Census of Agriculture, and shows that the 1995 respondents are representative of farms in the state. This section also examines the characteristics of different types of farms (dairy farms, other livestock operations, and crop farms), and discusses how their distinctive characteristics might influence manure and nutrient management behavior.

Enterprise Characteristics

The importance of animal agriculture to the state's farm sector is apparent in the fact that two-thirds of Wisconsin farms have some livestock as part of their operation. Most of these livestock farms milk cows for a living. As a result, issues regarding the proper management of manure are relevant to the majority of Wisconsin producers.

Table 1 presents selected enterprise characteristics of four different types of farms in the 1995 sample:

- **dairy farms** (all farms that reported presence of a milking dairy herd);
- **other livestock farms** (those without dairy cows who indicated that livestock sales comprised more than half of their gross receipts);
- **crop farms** (those without dairy cows who received most of their income from crop sales); and
- a group of "**mixed or unknown farm types**," (consisting mainly of farms with both crops and livestock, but who failed to tell us what commodities provided the bulk of their gross receipts).

Initially, it is evident that along many dimensions—farm enterprise types, mean acres operated, percent of farms in various sales and tenure classes, and percent of farms with no debt—our sample is quite representative of the farms in the 1992 Census.

The data in Table 1 also illustrate the heterogeneity of the Wisconsin farm population. Compared to other types of farms, dairy farms tend to be relatively large, with 90 percent reporting gross sales in excess of $40,000, and over half with sales of more than $100,000 in 1994. By contrast, roughly 80 percent of all other types of farm enterprises reported annual sales of less than $40,000. The larger scale of dairy farms often corresponds to greater debt levels; over a third of Wisconsin dairy operators report debt-to-asset ratios that exceed 40 percent (a common threshold used by economists to indicate early signs of financial stress or a high degree of debt leverage).

From a nutrient management perspective, the integration of crop and livestock production on a single farm provides unique opportunities to recycle nutrients in animal manures back into crop fields. The survey results suggest that most farms in Wisconsin are indeed diversified crop-livestock farms. For example, the majority of livestock farms report growing some corn for grain or silage (most of which is destined to be fed to their livestock). Cash grain farms appear to have the largest average corn acres, but corn production occurs on roughly 40 percent of all cropland on dairy and other livestock farms. Most corn in Wisconsin is raised in rotation with other crops; on average, less than a quarter of all corn ground is planted to corn for three or more years in a row (so-called "continuous corn rotation"). Rotating cropland with alfalfa, small grains, and soybeans provides further opportunities to optimize the cycling of nutrients within the farm.

The implications of these enterprise characteristics for nutrient and manure management behavior are complex. Since nearly 90 percent of all farms own at least half of their farm acreage, land stewardship issues are not likely to be dramatically affected by tenure status in Wisconsin. Meanwhile, the higher gross farm sales reported by dairy operations suggest that they may be better equipped to invest in manure handling structures than operators of other types of livestock enterprises, who are primarily small-scale, part-time farm businesses. As stated above, the availability of cropland on most dairy and other livestock farms suggests opportunities for on-farm disposal of animal manures in an environmentally sustainable way.[4]

Household Characteristics

The data in Table 2 indicate that dairy farm operators and their spouses are much less likely than operators and farm spouses on other types of enterprises to work off-farm. Those who work off-farm typically spend fewer hours per week at their jobs. Conversely, dairy farms rely more heavily on household members to assist in farmwork. These patterns reflect the labor-intensive nature and larger scale of dairy farming. Operators and family members of other livestock farms are more likely be working off-farm.

Although dairy enterprises tend to have more farm income, when off-farm income is factored in, dairy farms in our sample actually have noticeably lower total household incomes (combining farm and off-farm incomes) than other types of farms. Over 40 percent of dairy farms, compared to 20-30 percent of other types of farm households, reported total household incomes below $20,000 per year. On the upper end of the scale, less than a third of

Table 1. Selected Characteristics of Farm Enterprises and Households in Wisconsin[1]

	Enterprise Type					
	Dairy	Other Livestock	Crop	Mixed Type or Unknown	All Farms in the Sample	1992 Census of Agriculture
Number of farms in the sample	193	135	113	91	532	n.a.
Percent of farms in the sample	36.3	25.4	21.2	17.1	100.0	n.a.
Percent of farms in 1992 Census of Agriculture	(41.6)	(26.3)	(27.3)	(4.8)	(100.0)	n.a.
Acres operated (mean)	324.1	208.7	298.8	166.3	262.4	227.5
Ratio of acres owned to acres operated (mean)	78.0	87.3	83.9	90.4	83.6	n.a.
Operations by tenure class (percent)						
Full owners	36.6	67.7	68.2	80.0	58.3	57.1
Own 50% or more of acreage operated	52.2	23.3	18.2	12.5	31.0	34.4*
Own less than 50% of acres operated	7.5	6.8	10.0	6.3	7.7	*(incl. above)*
Full tenants	3.8	2.3	3.6	1.3	2.9	8.6
Total[2]	*100.1*	*100.1*	*100.0*	*100.1*	*99.9*	*65.7*
Percent of operations growing corn	95.3	66.9	73.4	43.0	75.0	54.0**
Acres of corn grown (mean)[3]	97.7	64.4	169.9	31.3	99.3	n.a.
Percent cropland planted to corn[3]	38.5	40.6	50.6	33.1	41.0	n.a.
Percent corn acreage in continuous corn rotation[3]	22.1	26.7	23.4	22.9	23.4	n.a.
Percent of farms by annual sales						
Less than $10,000	1.1	50.0	50.0	58.4	32.9	32.2
$10,000 to $39,999	10.1	26.9	25.9	26.0	20.2	20.7
$40,000 to $99,999	37.0	9.2	8.3	6.5	19.0	21.7
$100,000 to $249,999	41.8	9.2	9.3	7.8	21.2	20.3
More than $250,000	10.1	4.6	6.5	1.3	6.5	5.1
Total	*100.1*	*99.9*	*100.0*	*100.0*	*99.8*	*100.0*
Percent of farm households by debt-to-asset ratio						
No debt	22.3	52.6	58.5	64.7	44.7	41.3***
Debt is less than 10% of assets	7.4	13.5	8.5	3.5	8.6	n.a.
Debt is 10%-39% of assets	35.1	15.8	20.8	20.0	24.6	n.a.
Debt is 40%-79% of assets	29.8	14.3	10.4	10.6	18.6	n.a.
Debt is more than 80% of assets	5.3	3.8	1.9	1.2	3.5	n.a.
Total	99.9	100.0	100.1	100.0	100.0	

[1]Source: 1995 Wisconsin Farmer Poll and 1992 Census of Agriculture

[2]Totals may not equal 100 due to rounding.

[3]Data is for farms which grew corn.

*1992 Census of Agriculture data combines both those who own less than 50% of acreage and those who own more.

**1992 Census of Agriculture reports the number of farms which sold corn, which excludes those who grew but did not sell corn.

***1992 Census of Agriculture reports the proportion of farm operations with no interest expenses.

Table 2. Farm Household Characteristics[1]

	Enterprise Type					
	Dairy	Other Livestock	Crop	Mixed Type or Unknown	All Farms in the Sample	1992 Census of Agriculture
Operator age (mean)	48.3	51.4	55.6	57.4	52.1	50.6
Operators by age classes (percent)						
Under 35	13.2	10.9	5.4	4.8	9.5	13.2
35 to 44	28.9	21.7	17.9	11.9	21.9	23.1
45 to 54	26.3	27.1	24.1	23.8	25.6	22.5
55 to 64	22.6	18.6	25.0	25.0	22.5	21.4
Over 65	8.9	21.7	27.7	34.5	20.4	18.8
Total[2]	*99.9*	*100.0*	*100.1*	*100.0*	*99.9*	*99.0*
Operators by education completed (percent)						
Less than high school diploma	6.3	13.6	5.6	9.9	8.6	n.a.
High school diploma	44.3	42.4	33.6	40.7	40.9	n.a.
Some college[3]	43.7	32.0	48.6	32.1	39.8	n.a.
Bachelors degree or higher	5.7	12.0	12.1	17.3	10.7	n.a.
Total	*100.0*	*100.0*	*99.9*	*100.0*	*100.0*	n.a.
Percent of farm households with members working off-farm						
Operator works	18.0	64.7	49.0	55.6	42.9	43.7
Spouse works	33.2	61.6	50.0	46.9	46.1	n.a.
Either operator, spouse, or both work	39.2	80.9	60.9	67.9	59.1	n.a.
Mean share of all farmwork (percent)[4]						
Operator	60.0	69.4	65.0	64.7	64.2	n.a.
Other household members	35.6	28.3	22.7	26.4	29.5	n.a.
Non-household hired laborers	4.4	1.6	5.7	5.3	4.1	n.a.
Non-household unpaid laborers	0.2	0.7	6.6	3.6	2.3	n.a.
Total	*100.2*	*100.0*	*100.0*	*100.0*	*100.1*	n.a.
Future plans and expectations (percent)						
Farm one more year or less	20.2	17.4	18.5	30.9	20.8	n.a.
Farm 2 to 5 more years	30.6	23.5	26.9	17.3	25.8	n.a.
Farm 6 to 10 more years	18.0	9.1	10.2	9.9	12.7	n.a.
Indefinitely/sufficient farm returns	27.3	9.1	10.2	7.4	15.7	n.a.
Indefinitely/sufficient off-farm income	3.8	40.9	34.3	34.6	25.0	n.a.
Indefinitely (combined reasons)	31.1	50.0	44.5	42.0	40.7	n.a.
Percent of farm households by total family income						
Less than $9,999	13.4	13.7	12.1	11.9	13.0	n.a.
$10,000 to $19,999	26.9	16.8	17.8	14.3	20.3	n.a.
$20,000 to $34,999	26.9	26.7	32.7	29.8	28.5	n.a.
$35,000 to $49,999	10.2	16.0	21.5	20.2	15.7	n.a.
$50,000 to $74,999	12.4	21.4	10.3	11.9	14.2	n.a.
More than $75,000	10.2	5.3	5.6	11.9	8.3	n.a.

[1]Source: 1995 Wisconsin Farmer Poll and 1992 Census of Agriculture

[2]Results may not total 100 due to rounding.

[3]Includes A.A. or trade school degrees.

dairy farms have total household incomes of $35,000 per year or more, compared to around 40 percent of the other three farm types. Overall, this suggests that the lower levels of farm income on non-dairy operations are more than compensated for by higher levels of income from off-farm work and other sources.

Operators of dairy farms tend to be somewhat younger than those of other types of enterprises, reflecting the greater labor demands of dairy farming. As dairy farm operators age, they often move out of dairy farming and into less labor-intensive farm operations, such as beef, hay, and row crops. Dairy farm operators also complete higher levels of education than operators of other types of enterprises, with the exception of crop farms. Again, this partly reflects the younger age of dairy farm operators, since younger generations spend more years in school on average than did older generations. Crop farm operators, however, are most likely to have attended college.

When asked about their plans for the next 5 years, dairy farm operators are the *least* likely to report that they expect to leave farming in the next year. However, more than half of the dairy farmers report that they expect to quit farming within 5 years,[5] and fewer dairy farms expect to be able to continue farming indefinitely (31 percent compared to between 42 and 50 percent for other types of enterprises). Although plans to leave farming may not be very good predictors of actual exits, the short time horizons of those farmers who expect to leave farming within five years may well discourage them from making investments in manure management that may pay for themselves only over the long run. This will be discussed again below.

V. Typical Manure Management Practices on Wisconsin Livestock Farms

The Use of Recommended Manure Management Practices

Given the complexity of factors that must be considered to determine appropriate manure management practices for any one farm, it is difficult to identify "good" or "bad" management practices that would apply to all farms and in all situations. Over the last 15 years, however, many in the scientific and regulatory communities have focused on a particular set of practices that they perceive to be generally recommended (or discouraged) for protecting water quality (Powell, 1995; Sturgul and Bundy, 1996). As examples, Figure 1 classifies various types of manure storage and hauling practices as "recommended" or "discouraged."[6]

Table 3 describes the use of a range of manure storage and handling practices among all farms in our 1995 sample that reported having any livestock. One of the difficulties in characterizing manure management behavior is that a single farm may approach the handling of manure in multiple ways. As a result, we allowed respondents to give more than one answer to the survey questions about manure handling and hauling. The data reported here are sample frequencies for each type of practice. Because of the

Figure 1. Classification of Manure Management Practices

	Recommended	**Discouraged**
Type of Storage	• Storing manure in an improved storage facility (with the bottom sealed to prevent leakage into groundwater)	• Placing manure directly into the spreader • Storing manure in an unimproved facility or piling it on the ground
Time of Application	• Hauling mostly in the spring or fall when tillage is taking place • Incorporating manure into the soil shortly after spreading	• Hauling and spreading daily • Spreading manure on frozen ground that is steep or close to waterways

Table 3. Manure Handling Practices on Wisconsin Livestock Farms[1]
Spring 1995

	Enterprise Type		
	Dairy (n=193)	Other Livestock (n=205)	Overall (n=404)
	percent of farms in column		
What type of manure handling best describes your farm situation? *(Circle the number of all that apply)*[2]			
Put manure directly into spreader	76.2	44.9	60.1
Leave manure in barn/bldg (more than a few days)	21.8	48.3	35.4
Pile the manure on the ground	18.1	28.3	23.4
Store in an unlined manure storage basin	1.0	1.5	1.3
Store solid manure in a concrete pit	13.0	3.4	8.0
Store as liquid in a concrete pit	5.7	4.9	5.3
Store in a slurry system	2.1	1.0	1.5
Store in a clay-lined manure storage basin	7.8	2.0	4.8
Other	1.6	8.8	5.3
When is manure usually hauled?[2]			
Daily or frequently throughout the year	73.1	15.8	43.7
Same as above, but not in winter	2.1	3.9	3.0
Once a week for most of the year	5.7	11.3	8.6
Once a month for most of the year	4.7	16.3	10.6
Mostly in the spring	18.1	44.3	31.6
Mostly in the summer	2.1	7.9	5.1
Mostly in the fall	19.2	17.2	18.2
Mostly in the winter	1.6	3.9	2.8
Does not spread manure	0.0	3.4	1.8
COMBINATIONS			
Group A: Uses lined facility[3]	25.4	9.8	17.3
Group B: Hauls in spring or fall	28.5	52.7	40.9
Group C: Hauls daily or frequently throughout year	73.1	15.8	43.7

[1] Source: 1995 Wisconsin Farmer Poll

[2] Since respondents were allowed to check more than one option, column totals do not equal 100.

[3] Lined facilities include concrete pits, slurry system, or clay-lined storage basins.

multiple-answer format, the totals for each column will often exceed 100 percent.

We identified three important farm subgroups based on their manure storage or handling practices. The proportions of respondents that use one or more of various combinations of practices are summarized at the bottom of Table 3. These include those who reported having any type of lined storage facility, those who spread most of their manure in the spring or fall, and those who hauled manure daily. Because we did not have questions regarding crediting of nutrients from manure in the 1995 survey, we cannot report on how widespread that practice is in the state.

In general, the most common practices on Wisconsin livestock operations (both dairy and other livestock) are among the ones most frowned upon: putting manure directly into the spreader rather than storing it until the most appropriate times to haul, piling manure directly on the ground, and spreading manure daily. Roughly three out of four Wisconsin dairy farm enterprises report that they put their manure directly in a spreader and haul daily or frequently throughout the year. More than one-fifth report leaving their manure in a barn or other building for more than a few days, and 18 percent pile manure directly on the ground. Less than a third (28 percent) of all dairy farms report applying most of their manure in either the spring, fall, or both.

In some respects, non-dairy livestock enterprises appear to be more likely than dairy farms to follow recommended manure handling procedures. They are less likely than dairy farms to put manure directly into the spreader, and far less likely to haul manure daily or frequently throughout the year. Indeed, over half report that they spread most of their manure in the spring or fall. At the same time, non-dairy livestock operators are less likely to have any type of lined manure storage facility and are much more likely to leave manure in the barn or other building for more than a few days or pile their livestock manure directly on the ground.

Despite significant public investment subsidizing the construction of improved manure storage structures in Wisconsin in recent years, the use of such structures—typically a concrete pit, a slurry system, or a clay-lined basin—remains rather low. The data for "Group A" at the bottom of Table 3 reflect the proportion of each type of farm that report the use of at least one of the four types of lined storage facilities. Among the respondents, dairy farms are the most likely of all farm types to have installed improved manure storage structures. Nonetheless, only 25.4 percent of dairy farms, and less than 10 percent of other livestock farms, report using these structures.

Although livestock operations may have adequate cropland to spread manures generated by their livestock, it is not always the case that farmers spread manure equally across all of their fields. In particular, Nowak et al. (1996) noted that farmers often put more manure on fields that are closest to their barnyards, resulting in excessive concentrations of nutrients in some fields, and too few nutrients in others. Table 4 indicates the proportion of dairy and other livestock enterprises that spread manure within five minutes of their barns. Unlike the questions addressed in Table 3, respondents were only allowed to indicate one response for each of the questions listed in Table 4. The results suggest that most manure in Wisconsin is spread on fields within five minutes of the barn by tractor, and that there is little difference between dairy and other livestock farms in this regard. However, due to data limitations, we were not able to control for such factors as farm size, volume of manure spread, use of additional fertilizers, and the specific layout of farm fields on individual farms. Thus, while the evidence suggests that manure is being applied unevenly by field, we cannot conclude that this behavior necessarily constitutes an environmental risk in each situation.

The type of surface used in the main livestock yard has been linked to the likelihood and rate of nutrient leaching into groundwater supplies. Generally, concrete is preferable to soil, crushed rock, or gravel as a livestock yard surface, because it prevents leaching more effectively. Moreover, since it is the easiest of the surfaces to clean, concrete yards typically have less buildup of manure and urine. The results in Table 4 reveal that dairy enterprises are almost twice as likely to have concrete barnyards than other livestock enterprises. The majority of non-dairy livestock farms use soil livestock yards. Crushed rock or gravel surfaces are the least common in both groups.

The destination of runoff water from the main livestock yard can be a good indicator of the likelihood of local surface water contamination. The survey results (displayed in Table 4) suggest that most livestock yards drain into adjacent fields, where nutrients in runoff may or may not be absorbed by soil or crops before reaching surface waters. A

Table 4. Manure Handling Practices on Wisconsin Livestock Farms, Part II[1]
Spring 1995

	Enterprise Type		
	Dairy (n=193)	Other Livestock (n=205)	Overall (n=404)
	percent of farms in column		
Percent of manure spread on fields within 5 minutes of barn by tractor			
None--does not spread manure	0.0	4.4	2.3
Less than 10 %	5.7	5.4	5.6
10 - 49 %	17.7	9.3	13.4
50 - 74 %	13.5	10.8	12.2
75 - 89 %	10.4	5.9	8.1
90 % or more	52.8	63.5	58.3
Don't know	0.0	0.5	0.3
Total[2]	*100.1*	*99.8*	*100.2*
Main or largest livestock yard surface			
Soil	27.3	51.4	39.6
Concrete	64.8	33.9	49.0
Crushed rock/gravel	5.1	8.7	7.0
Other	2.8	6.0	4.4
Total	*100.0*	*100.0*	*100.0*
Runoff water flows from main livestock yard			
Into engineered filter strip	12.8	4.6	8.5
Into adjacent field	56.7	60.2	58.5
Into farmyard	12.8	16.8	14.9
Into roadside ditch	2.8	3.1	2.9
Into nearby stream or pond	2.8	2.6	2.7
Other/Not sure	12.2	12.8	12.5
Total	*100.1*	*100.1*	*100.0*
Percent reporting difficulties meeting manure storage regulations or guidelines	1.0	1.9	1.5
Percent who have experienced neighbors' complaints	2.1	1.9	2.0

[1] Source: 1995 Wisconsin Farmer Poll

[2] Totals may not equal 100 due to rounding.

relatively small fraction of Wisconsin livestock farms (8.5 percent) use engineered filter strips to protect water supplies, though dairy farms are almost three times more likely to use such an arrangement than other livestock enterprises[7]. Only 1 in 20 dairy and other livestock operations report that the runoff from their main livestock yards flows directly into a roadside ditch or a nearby stream or pond, a situation that would be most likely to produce adverse environmental impacts.[8]

In recent years, anecdotal reports of farmers suffering undue hardships due to state environmental regulations and complaints from nonfarming neighbors about smells from their farming operations have become common. However, as listed at the bottom of Table 4, only 1 in 100 of dairy operators and 1 in 50 of other livestock operators in our study report that they have had difficulties in meeting current manure storage regulations or guidelines. The fact that *current* rules have not created much of a problem for producers is perhaps not surprising given that most programs offer to pay for changes when they are required, and that only a very small percentage of dairy farmers and other livestock operators currently meet the size criteria for stricter manure management regulation in Wisconsin.[9] Similarly, only 1 in 50 livestock operators report having experienced neighbors' complaints about odors, flies, or noise from their farming operation. As will be discussed below, the lack of current conflicts with state regulators or neighbors has not lessened the anxiety that many livestock producers feel about possible *future* regulation and conflicts.

Overall, the results of the 1995 survey suggest that dairy farmers are generally more likely to have installed expensive structures designed to prevent environmental contamination—including lined manure storage facilities, concrete livestock yards, and engineered filter strips to handle barnyard runoff. At the same time, dairy farms are also more likely to spread their manure daily throughout the year, and just as likely to spread most of their manure on fields relatively close to their barns.

Environmental Concern and Policy Preferences of Wisconsin Farm Operators

In addition to information about the management practices and characteristics of farms and farm households, the 1995 Wisconsin Farmer Poll also included questions designed to measure the views and opinions of a representative sample of Wisconsin farm operators concerning issues of environmental protection and manure management. Concern about environmental impacts is often considered a precondition for changing manure management behavior. As a result, a considerable amount of effort has been devoted toward educating farmers about the magnitude of the problem and the technological or managerial solutions available to mitigate environmental impacts. The small proportion of farmers using recommended practices (discussed above) suggests that there may well be a lack of concern about environmental problems among Wisconsin farmers. This section is designed to provide a profile of the attitudes and opinions of our farmer sample on a range of environmental topics. The percent of farmer respondents who agree or strongly agree with a number of statements or questions are summarized in Tables 5 and 6. The responses are presented separately for three different groups of farm operations (dairy farms, farms with other kinds of livestock, and farms that have no livestock).

The data in Table 5 explore the degree to which Wisconsin farmers are concerned about environmental impacts from farming practices. The results suggest that while farmers are skeptical about criticism of agriculture by the nonfarming public (particularly by environmentalists), a clear majority of producers agree that there is room for improvement in the environmental performance of Wisconsin agriculture. Over seventy percent of the farmer respondents (and eighty percent of the dairy farmers) agree that manure management is a critical issue in the livestock industry, and a majority feel that Wisconsin farmers must "do a better job of environmental protection." Interestingly, a relatively small proportion of Wisconsin farmers believe that "the environmental costs of large-scale livestock operations have been exaggerated."

The data in Table 6 summarize Wisconsin farmers' assessments of the need for more environmental regulation and their preferences for various agricultural and environmental policies. It appears that the state's producers are quite split in their opinions about whether more stringent regulations are required to protect the environment. Strict regulation of "confinement livestock facilities" is supported by 50.1 percent of the respondents, while 44.7 percent agree that "government should regulate certain farming practices and land uses to reduce underground and surface water pollution." While

Table 5: Farmers' Concerns about Environmental Issues and Agriculture

Statement or Question	Dairy Farms	Other Livestock Farms	Non-Livestock Farms	All Wisconsin Farms
	percent who agree or strongly agree with statement			
When all is said and done, Wisconsin is a farm state and non-farm people need to get accustomed to the noise and odors associated with livestock.	79.5	77.4	75.6	77.8
The noise, odors, and associated environmental problems from confinement livestock operations are minimal when compared to industrial pollution from factories in Wisconsin's towns and cities.	75.8	73.9	68.3	73.4
Increasingly, manure management is a critical issue in the livestock industry.	80.3	61.4	71.1	70.4
Much of the controversy surrounding livestock facilities and protection of the environment is because environmentalists don't understand modern farming.	74.0	66.6	65.6	69.0
There is room for improvement in the environmental performance of Wisconsin agriculture.	67.4	66.9	67.4	67.7
Wisconsin farmers must do a better job of environmental protection if they are to have the support of the general public.	51.8	61.0	59.6	57.2
The environmental costs of large-scale livestock operations have been greatly exaggerated.	36.2	38.3	33.9	36.7

they appear to be somewhat skeptical about tightening regulations in the future, less than 50 percent of the respondents feel that current environmental rules on confinement livestock operations have gotten too strict.

Criticism of environmental rules and regulations in general belies much higher levels of support for requiring farmers to adopt certain management practices. The results in the middle section of Table 6 indicate that clear majorities of Wisconsin farmers support rules that require operators to keep records of pesticide use and to write manure management plans. A surprisingly large proportion of farmers (56.9 percent) agree that "farmers should be required to plant grass protection strips along stream banks and waterways." There was less support for the idea that large-scale operations should be located in places which minimize conflicts with the nonfarm public, and fewer than 2 in 5 farmers agree that draining wetlands for agricultural uses should be restricted.

The data at the bottom of Table 6 summarize responses to statements about who should pay for costs imposed by environmental regulations. Here it is quite clear that the overwhelming majority of farm operators believe that farmers should be compensated by the government for the costs of complying with environmental restrictions. Less than 30 percent of all farmers agree that farmers should "pay most of the costs of environmental protection."

Throughout Tables 5 and 6, several important differences appear to be associated with the type of

Table 6: Wisconsin Farmers' Preferences for Various Agricultural and Environmental Policies

STATEMENT OR QUESTION	Dairy Farms	Other Livestock Farms	Non-Livestock Farms	All Wisconsin Farms
	percent who agree or strongly agree with statement			
IS REGULATION NEEDED OR DESIRABLE?				
Strict environmental regulation of confinement livestock facilities is needed because a few farmers will abuse the environment unless forced to do otherwise.	51.6	46.6	54.7	50.1
Government should regulate certain farming practices and land uses to reduce underground and surface water pollution.	42.3	45.0	47.9	44.7
Environmental rules and regulations and pollution laws on confinement livestock facilities have gotten too strict.	46.3	49.0	45.3	47.0
Our livestock management laws have gotten so strict that many operations are moving to other states with fewer regulations.	35.7	42.6	39.3	39.4
WHAT KINDS OF BEHAVIOR SHOULD BE REQUIRED?				
Farmers should be required to keep application records on their use of all agricultural pesticides.	64.9	68.0	69.3	67.3
All livestock producers should develop manure management plans to protect themselves from nuisance suits.	64.6	53.6	67.8	60.8
To protect water quality, all farmers should be required to plant grass protection strips along stream banks and in waterways.	51.1	61.2	58.9	56.9
Large-scale livestock operations should be located in regions of the state where they will not interfere with the public's enjoyment of the outdoors.	38.3	38.3	46.6	40.1
Farmers should not be permitted to drain wetlands and plant crops on these lands.	31.2	45.7	40.3	39.3
WHO SHOULD PAY FOR ENVIRONMENTAL REGULATIONS?				
When government regulations reduce farm property values, the owner should be paid for this loss.	80.3	79.3	75.0	78.6
Farmers should be compensated for planting grass protection strips along stream banks and in waterways.	83.2	73.5	75.8	77.4
If farm practices cause environmental damage, the public should expect farmers to pay most of the costs of environmental protection.	27.6	27.9	30.9	28.5

farm operation. Dairy farmers are much more likely to believe that "manure management is a critical issue" than farmers who raise other kinds of livestock. However, they are also more likely to believe that much of the "problem" is attributable to misunderstanding of agriculture by the nonfarming public, and are the least likely to agree with the statement that "Wisconsin farmers must do a better job of environmental protection." Compared to other livestock farmers and non-livestock farm operators, dairy farmers are least likely to support general government regulations to protect water quality, and are less supportive of specific rules (such as mandatory record keeping, writing manure management plans, and requirements to plant grass strips) designed to reduce environmental impacts. Dairy farmers feel most strongly that farmers should be compensated for the costs incurred in complying with environmental regulations.

Relationship between Attitudes and Manure Management Behavior

Taken as a whole, the results in Tables 5 and 6 suggest a considerable diversity among Wisconsin farmers in their assessments of current environmental problems and regulations, and in their views about what kinds of policies might be necessary to mitigate environmental impacts. It certainly appears that the relatively low rates of adoption of "recommended" manure management practices documented above are not directly caused by a "lack of concern" about the environmental impacts of farming activities. Clear majorities of Wisconsin livestock farmers support the need for industry-wide improvements in management practices, though only a small fraction are building lined manure storage facilities, spreading and incorporating manures in the spring or fall, and designing barnyards to minimize potential manure runoff. Other explanations for a failure to follow recommended guidelines need to be explored. It is likely that many who are not following manure management recommendations feel that they cannot afford the time or money to make the necessary improvements or that public subsidies should be made more available to accomplish environmental goals that contribute to the well being of society as a whole.

VI. Manure Storage and Handling Practices among Wisconsin Dairy Farms

Any attempt to analyze patterns of manure management behavior on Wisconsin farms is complicated by the fact that different types of livestock pose distinct challenges in terms of waste production, concentration, and disposal. Dairy farms are of particular interest because they are the most common type of livestock operation in the state, they are typically much larger (in terms of animal numbers per farm) than other kinds of livestock farms, and because milk production requires especially careful management of manure to comply with statutory sanitation guidelines. Compared with beef producers (the second largest livestock group), for example, dairy farmers bring their animals indoors at least twice a day, and many keep the animals confined indoors year-round. Dairy farmers thus have a greater need to dispose of manure on a daily basis. Also, the relentless work schedule of a dairy farmer makes it more difficult to free up labor for manure handling, particularly during planting and harvesting seasons when manure spreading can be done with the least environmental risk. To better understand manure management behavior on dairy farms, this section of the report focuses on dairy operations only.

Manure Management Practices by Dairy Herd Size

The following tables outline the proportion of dairy farms in different herd-size classes that utilize the manure management practices discussed above. This approach addresses the question of whether or not the increasing number of relatively large dairy herds in the state might be associated with greater potential environmental impacts. Larger dairy operations are often seen as posing a greater risk[10] of nutrient contamination because they may have: (1) greater levels of manure production and larger numbers of animals concentrated around buildings and barnyards; (2) heavier reliance on purchased feeds, which import more nutrients onto the farm; and (3) greater animal-to-land ratios than other dairy systems, leaving them proportionately less cropland for ecologically sustainable manure spreading, even if feed rations are balanced and nutrients from manure

are credited. On the other hand, as outlined above, larger dairy farms are also likely to have greater financial and managerial resources to devote to the careful management of livestock wastes.

The data at the top of Table 7 illustrate the proportion of dairy herds in our sample that were in each of four different size categories. Despite the perception of some that it has become outmoded, our results illustrate how the traditional small to mid-sized, family-labor dairy farm (milking between 25-99 cows) still accounts for the vast majority of operations in the state. Put differently, the relatively large dairy herds that have received significant attention from the farm press and industry leadership in recent years (those with more than 100 milking cows) comprised less than 10 percent of herds in the spring of 1995.

The second line on Table 7 summarizes the average number of acres of cropland (both owned and rented) that is available per milking cow on dairy farms of different sizes[11]. The results confirm that larger dairy farms have less cropland acreage per milk cow than smaller dairy farms. It is noteworthy, however, that the differences are not as striking as many have thought, and it is only among the smallest dairy herds (under 25 cows) that there is a statistically significant increase in acreage per cow. Using the results of a parallel survey of a larger sample of Wisconsin dairy herds also conducted by our institute in the spring of 1995,[12] we can graph the relationship between dairy herd size and cropland availability. As shown in Figure 2, the proportion of farms with relatively low amounts of cropland available for spreading dairy manure does not differ significantly among different herd size classes. Moreover, the vast majority of Wisconsin dairy farms still have at least 3 acres of cropland available per milking cow which should be sufficient for optimal manure disposal (see discussion in Sturgul and Bundy, 1996). The results show that, at least up to now in Wisconsin, larger operations appear to have increased their cropland acreages proportionately as they have increased their herd sizes.

The data in Table 7 also illustrate the percent of dairy farms in each size category that use certain kinds of manure storage and handling practices. Our findings show that, regardless of their size, most dairy farms put manure directly into the spreader at some point during the year. However, as dairy herd size increases, so does the likelihood that the operation uses a lined manure storage facility. Indeed, farms with the largest herd sizes are ten times more likely than those with the smallest size herds to use such a facility (56.3 percent versus 5.6 percent). The likelihood of manure being piled on the ground or stored in an unlined manure storage basin is also closely related to herd size; more than a quarter of dairy farms with the smallest size herds report using this practice, while only 3 in 50 dairy farms with the largest size herds report it.

Farms with larger herds report lower rates of daily or frequent hauling of manure throughout the year than do farms with smaller herds—again, this is to be expected given the lower rates at which storage facilities are found on smaller farms. This relationship, however, is not direct: the rates reported by the farms with the largest herds are not as low as might be expected given the prevalence of storage facility use among these farms. While those farms with larger herds are more likely to report spreading most of their manure in the fall, there is virtually no difference by scale in the frequency of reporting hauling most of an operation's manure in the spring. Because many operators reported both spring and fall spreading, the combined percent of those who haul mainly in the spring, fall, or both are listed at the bottom of Table 7. Here a clear relationship between herd size and increased spring or fall spreading is evident. Of those few farms reporting that most of their manure spreading occurs in the winter, all are operations with smaller herd sizes.

Table 8 shows that dairy operations with larger herds are generally more likely to use practices that minimize the risks of nutrient runoff and leaching from dairy cow manures. Specifically, larger dairy farms are more likely to spread more of their manure farther away from the barn than are operations with smaller herds.[13] However, the results show that even among those farms with the largest herd sizes, 75 percent of manure is spread on fields within five minutes by tractor. Scale is also directly associated with the presence of a concrete surface in the main livestock yard: while only about one-third of farms with the smallest size herds have concrete livestock yards, more than 90 percent of those with the largest size herds have concrete yards. Of those farms without concrete yards, soil is the most prevalent yard surface. Finally, larger dairy herds are somewhat more likely to have an engineered filter strip installed to handle barnyard runoff water.

Table 7. Manure Handling Practices on Wisconsin Dairy Farms[1]
By Dairy Herd Size, Spring 1995

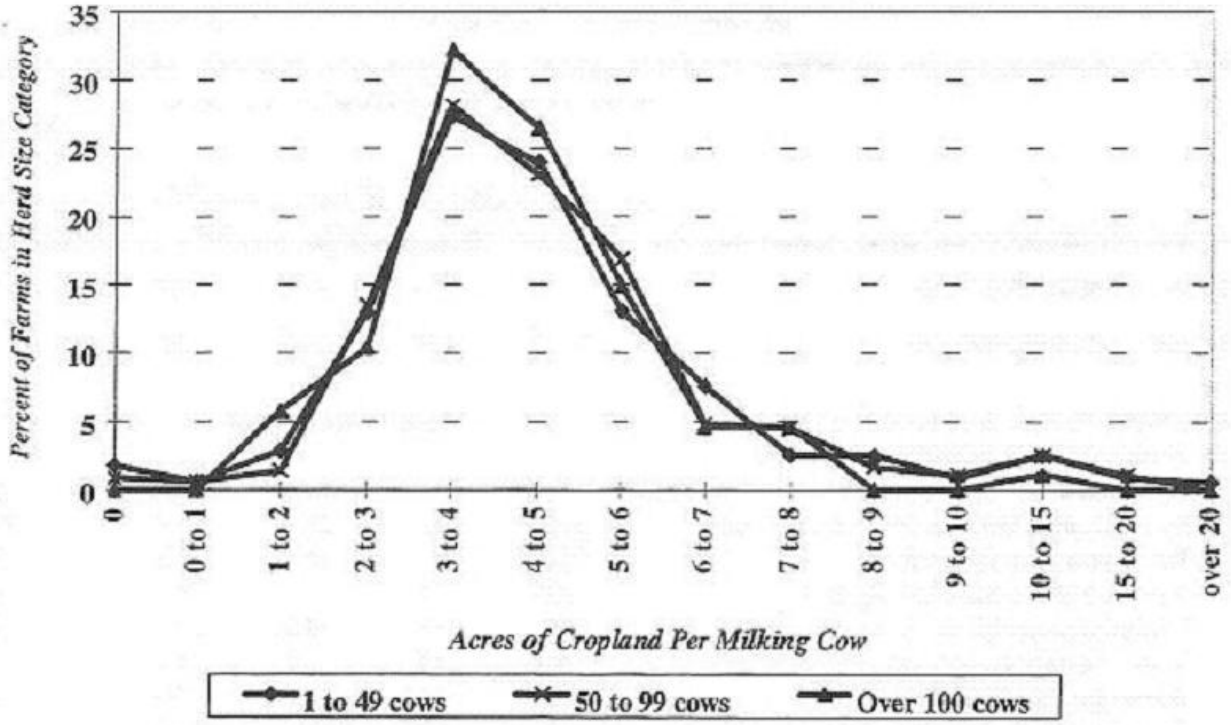
	Herd Size (Cows)				
	1 to 24 (n=18)	25 to 49 (n=79)	50 to 99 (n=71)	Over 100 (n=16)	All Dairy Farms in the Sample (n=193)
Percent of sampled dairy farms	9.8	42.9	38.6	8.7	100.0
Acres of cropland per cow (mean)	7.96	4.12	4.44	3.89	4.59
What type of manure handling best describes your farm situation? *(Circle the number of all that apply)*[2]	*percent of farms in column*				
Put manure directly into spreader	77.8	81.0	74.6	68.8	76.2
Leave manure in barn/bldg (more than a few days)	16.7	20.3	25.4	18.8	21.8
Pile the manure on the ground	27.8	22.8	12.7	6.3	18.1
Store in an unlined manure storage basin	0.0	1.3	1.4	0.0	1.0
Store solid manure in a concrete pit	5.6	8.9	18.3	18.8	13.0
Store as liquid in a concrete pit	0.0	3.8	4.2	31.3	5.7
Store in a slurry system	0.0	0.0	5.6	0.0	2.1
Store in a clay-lined manure storage basin	0.0	5.1	5.6	43.8	7.8
Other	0.0	1.3	2.8	0.0	1.6
When is manure usually hauled?[2]					
Daily or frequently throughout the year	66.7	81.0	70.4	56.3	73.1
Same as above, but not in winter	11.1	1.3	1.4	0.0	2.1
Once a week for most of the year	11.1	5.1	5.6	0.0	5.7
Once a month for most of the year	0.0	3.8	5.6	12.5	4.7
Mostly in the spring	16.7	17.7	18.3	18.8	18.1
Mostly in the summer	0.0	0.0	4.2	6.3	2.1
Mostly in the fall	11.1	16.5	21.1	37.5	19.2
Mostly in the winter	5.6	2.5	0.0	0.0	1.6
Does not spread manure	0.0	0.0	0.0	0.0	0.0
COMBINATIONS:					
Group A: Uses lined facility[3]	5.6	17.7	33.8	56.3	25.4
Group B: Hauls in spring or fall	22.2	26.6	31.0	37.5	28.8
Group C: Hauls daily or frequently throughout year	66.7	81.0	70.4	56.3	73.1

[1] Source: 1995 Wisconsin Farmer Poll

[2] Since respondents were allowed to check more than one option, column totals do not equal 100.

[3] Lined facilities include concrete pits, slurry system, or clay-lined storage basins.

Figure 2: **Percent of Dairy Farms with Various Amounts of Cropland Available per Milking Cow, By Dairy Herd Size, Spring, 1995.**



(It is interesting, however, that the smallest herds were also more likely to have these filter strips installed.)

The data at the bottom of Table 8 suggest that very few dairy farms report difficulties meeting manure storage guidelines or regulations. Although overall few dairy farms reported having had complaints from neighbors, none of the herds with less than 50 cows reported complaints, while one in eight of the dairy farms with the largest herds did report such a problem.

Characteristics of Manure Handling Practice Groups

To better understand the characteristics of the dairy farms whose operators do (and do not) use recommended manure storage and handling practices, we identified three key groups of dairy farms based on their manure management behavior. Some selected farm enterprise and household characteristics of each group are given in Table 9. These groups are: (a) those dairy farms that have installed lined storage facilities; (b) those who field apply manure mainly in the spring or fall; and (c) those who report hauling most of their manure daily or frequently throughout the year. The results illustrate some important differences between users and non-users of key practices, and provide direction to researchers and extension staff who want to target their future efforts to those clientele with the greatest potential for improved manure management.

Group A: Dairy enterprises with lined storage facilities

Dairy farm operators who have installed lined facilities tend to have larger operations, more cropland, be younger, and have more years of education than those who do not have such facilities. Conversely, those who have not installed improved storage structures have smaller herds, larger proportions of their acreage in pasture, and tend to be older and to have fewer years of formal education. Interestingly, the ratio of available cropland to numbers of milk cows does not seem related to the presence of storage facilities; this suggests that

Table 8. Manure Practices on Wisconsin Dairy Farms, Part II[1]
By Dairy Herd Size, Spring 1995

	Herd Size (Cows)				
	1 to 24 (n=18)	25 to 49 (n=79)	50 to 99 (n=71)	Over 100 (n=16)	All Dairy Farms in the Sample (n=193)
	percent of farms in column				
Percent of manure spread on fields within 5 minutes by tractor					
None--does not spread manure	0.0	0.0	0.0	0.0	0.0
Less than 10 %	11.1	5.1	4.2	12.5	5.7
10 - 49 %	5.6	17.8	19.6	18.8	17.7
50 - 74 %	22.2	13.9	12.7	12.5	13.5
75 - 89 %	0.0	5.1	11.3	37.5	10.4
90 % or more	61.1	58.2	52.1	18.8	52.8
Don't know	0.0	0.0	0.0	0.0	0.0
Total[2]	*100.0*	*100.1*	*99.9*	*100.1*	*100.1*
Main or largest livestock yard surface					
Soil	38.5	38.9	17.6	6.3	27.3
Concrete	38.5	52.8	76.5	93.8	64.8
Crushed rock/gravel	23.1	2.8	4.4	0.0	5.1
Other	0.0	5.6	1.5	0.0	2.8
Total	*100.1*	*100.1*	*100.0*	*100.1*	*100.0*
Runoff water flows from main livestock yard					
Into engineered filter strip	20.0	14.7	7.6	26.7	12.8
Into adjacent field	66.7	50.7	59.1	46.7	56.7
Into farmyard	13.3	6.7	18.2	20.0	12.8
Into roadside ditch	0.0	2.7	4.5	0.0	2.8
Into nearby stream or pond	0.0	5.3	1.5	0.0	2.8
Other/Not sure	0.0	20.0	9.1	6.7	12.2
Total	*80.0*	*85.4*	*92.4*	*73.4*	*87.3*
Percent reporting difficulties meeting manure storage regulations or guidelines	0.0	1.3	1.4	0.0	1.0
Percent who have experienced neighbors' complaints	0.0	0.0	2.9	12.5	2.1

[1] Source: 1995 Wisconsin Farmer Poll

[2] Totals may not equal 100 due to rounding.

Table 9. Selected Characteristics of Farm Enterprises and Households in Wisconsin by Manure Handling Practice Groups[1]
Wisconsin Dairy Farms, Spring 1995

	Group A Has lined manure storage facility		Group B Hauls manure mainly in the spring or fall		Group C Hauls manure daily	
	Yes (n=48)	No (n=141)	Yes (n=54)	No (n=135)	Yes (n=139)	No (n=50)
Percent of all dairy farms by annual sales						
Less than $10,000	0.0	1.4	1.9	0.7	0.7	2.0
$10,000 to $39,999	4.2	21.1	7.4	11.1	9.4	12.0
$40,000 to $99,999	20.8	42.6	29.6	40.0	42.4	22.0
$100,000 to $249,999	56.3	36.9	50.0	38.5	39.6	48.0
More than $250,000	18.8	7.1	11.1	9.6	7.9	16.0
Total[2]	*100.1*	*109.1*	*100.0*	*99.9*	*100.0*	*100.0*
Farm acreage						
Mean total operated	378.5	304.6	305.4	331.5	319.7	335.6
Mean percent owned	80.7	77.0	82.7	76.4	76.8	81.0
Mean percent cropland	77.4	67.7	73.3	69.1	69.6	72.1
Mean percent pasture	9.6	16.8	11.7	16.2	15.3	13.8
Mean percent CRP	1.2	0.6	0.8	0.8	0.7	1.0
Mean cropland/cow ratio	3.6	3.4	3.0	3.7	3.7	3.0
Mean dairy herd size	84.0	45.6	60.2	53.4	49.1	72.4
Median dairy herd size	60	40	50	43	45.0	52
Operator age (mean)	45.0	49.4	48.7	48.1	48.1	48.8
Operators by education completed (percent)						
Less than high school diploma	2.1	7.9	3.8	7.4	7.2	4.1
High school diploma	38.3	46.5	50.0	41.8	44.0	44.9
Some college[2]	55.3	39.4	42.3	44.3	43.2	44.9
Bachelors degree or higher	4.3	6.3	3.8	6.6	5.6	6.1
Total[2]	*100.0*	*100.1*	*99.9*	*100.1*	*100.0*	*100.0*
Percent of farm households with members working off-farm						
Operator works	18.2	18.0	17.0	22.6	18.9	15.6
Spouse works	32.7	33.3	37.0	31.2	33.1	33.3
Either operator, spouse, or both work	36.7	40.0	42.6	37.8	39.9	37.3

[1]Source: 1995 Wisconsin Farmer Poll

[2]Results may not total 100 due to rounding.

[3]Includes A.A. or trade school degrees.

increased land pressure is not a significant factor in explaining why some farmers choose to install lined storage structures. Similarly, there are no noticeable differences in the tenure status or degree of off-farm work participation between users and non-users of storage structures.

Group B: Dairy enterprises that spread most manure in the spring and/or fall

The main purpose of a lined storage facility is to enable producers to store livestock wastes for extended periods of time, and to spread them at a time of year when they can quickly incorporate manures into the soil. This practice maximizes the availability of manure nutrients to crops, and minimizes the risks that nutrients will runoff the soil surface into nearby surface waters. The middle two columns in Table 9 present the characteristics of dairy farmers who reported hauling most of their manure during the spring or fall. The results suggest that farmers who spread manure in the spring or fall had significantly fewer acres of cropland per milk cow. This is due to having on average both larger dairy herds and less cropland. Farmers in this group also owned a higher fraction of their acreage and were less likely to work at an off-farm job (though their spouses were *more* likely to work off-farm). Age and education variables were not statistically different for farmers who did or did not spread in the spring or fall.

Group C: Dairy enterprises that haul most manure daily throughout the year

In the far right columns of Table 9, the distinguishing characteristics of those farms that report hauling most of their manure either daily or frequently throughout the year appear to reflect similar patterns. On average, daily haulers tend to have smaller herds and less cropland (though mid-sized operations are more likely to haul daily than either the smallest or largest dairy farms). These farms also report more acres of available cropland per milking cow, suggesting a relationship between increased availability of land and the frequency of manure hauling. On a number of important variables—the age or education of the operator, whether or not the farmer works off the farm, and the proportion of land that is owned by the operator—there do not appear to be any systematic relationships to daily hauling activities.

Overlap Among Manure Handling Practice Groups

While the results discussed above suggest that there is a strong relationship between scale of operation and the use of a lined manure storage facility, it turns out that the presence of such a facility—which has environmental benefits only because it allows manure to be stored over long periods of time and then spread at critical times when it can be incorporated into the soil—does not always guarantee that farmers will stop spreading much of their manure on a daily basis. Tables 10 and 11 provide cross-tabulations of the proportion of all dairy farmers who use lined storage facilities versus the proportion who are spreading most of their manure daily or in the spring. The results suggest that even among those who have lined facilities, a significant proportion (roughly one in five) continue to haul manure daily or frequently throughout the year, essentially reducing much of the potential benefit of these structures.[14] Of those dairy enterprise operators who did *not* report using a lined facility (i.e., they were not members of Group A), 67.9 percent haul manure daily, and 68.4 percent do *not* haul in the spring.

Moreover, a recent study by Nowak et al. (1996) shows that although farmers with storage facilities are more likely to credit the nutrient contributions of manure than those without, even farmers with storage facilities still frequently exceed recommended nutrient application rates on their most productive corn fields by significant amounts. If the point of a storage facility is to abate these problems, and not simply to relieve farmers of the need to haul manure daily, then "structures alone . . . are a poor and costly technological solution to improper manure management," in their view (p. 24).

Table 10: Cross Tabulation of Manure Storage Facility and Daily Spreading Behavior
Percent of All Wisconsin Dairy Farms, Spring, 1995[1]

		Hauls Most Manure Daily		
		YES	NO	Total
Uses Lined Manure Storage Facility	YES	5.2	20.2	*25.4*
(concrete or clay-lined pit or slurry system)	NO	67.9	6.7	*74.6*
	Total	*73.1*	*26.9*	100.0

[1] Source: 1995 Wisconsin Farmer Poll

Table 11: Cross Tabulation of Manure Storage Facility and Spring Hauling Behavior
Percent of All Wisconsin Dairy Farms, Spring, 1995[1]

		Hauls Most Manure in the Spring or Fall		
		YES	NO	Total
Uses Lined Manure Storage Facility	YES	19.2	6.2	*25.4*
(concrete or clay-lined pit or slurry system)	NO	9.3	65.3	*74.6*
	Total	*28.5*	*71.5*	100.0

[1] Source: 1995 Wisconsin Farmer Poll

VII. Summary and Conclusions

Wisconsin's temperate climate, rolling terrain, and long history of diversified family farms make livestock production a natural fit for the state. In 1994, almost 75 percent of all cash receipts on Wisconsin farms came from the sale of livestock and livestock products (WASS, 1996). Dairy farming, in particular, has provided the economic and cultural backbone of many rural communities. Recent research estimates that upwards of 17 billion dollars are generated for the state's economy by milk sales and the processing of milk products every year (Deller et al., 1994).

Although most people recognize the importance of livestock to Wisconsin, in recent years there have been increasing public concerns about possible impacts of manure on water quality in the state. Although the actual scale of the problem has been poorly quantified, it is clear that excessive[15] application of agricultural nutrients (particularly phosphorus and nitrogen) from both commercial fertilizers and manures has adversely affected ground and surface water quality in the state. In response to these concerns, university scientists and public extension educators have worked to develop and promote manure management and crop rotation systems that maximize the on-farm utilization of manure nutrients and minimize the risks of water contamination.

Because Wisconsin's farms are also typically diversified crop-livestock enterprises—that is, they have sufficient cropland acreage for their livestock numbers to make manure spreading viable—they have options for manure disposal that are unavailable to the more specialized livestock farms ("industrialized" or "drylot" farms with very low ratios of cropland to animal units) typical of the great plains, the southwest, and the western portions of the U.S.. In addition, manure can greatly decrease the need for commercial fertilizers on crop fields, potentially saving producers significant amounts of money and contributing to a more "sustainable" production system. As a result, most recommended manure management practices in Wisconsin involve systems that store livestock wastes for extended periods of time and then incorporate them into the soil when fields are prepared for crop planting. To do this effectively, it is necessary to have "improved" manure storage structures, to incorporate manures when they are spread, and to reduce the application of commercial fertilizers based on "credits" for nutrients contributed by manure.

This report has examined the use of a selected set of manure management practices among a large random sample of Wisconsin farm enterprises in the spring of 1995. In this final section, we review the main findings from our research, discuss some of the factors that might account for the observed behaviors, and then offer some tentative suggestions for how future manure research and extension programs might be adjusted to be more effective.

Main Findings

The results of the 1995 Wisconsin Farmer Poll indicate that **the most common manure management practices found on all types of Wisconsin livestock operations are among those with the greatest potential for negative impacts on water quality**. These include:

1. hauling and spreading manure daily;
2. concentrating manure spreading in areas closest to barns;
3. storing manure in places where it may pose a threat of nutrient runoff or leaching; and
4. failing to install concrete surfaces and filter strips to control barnyard runoff.

In addition, despite considerable public investment designed to subsidize the construction of lined manure storage facilities in Wisconsin, **most Wisconsin livestock operations still do not have safe long-term storage facilities for manure**. In the spring of 1995, only 17 percent of livestock farmers reported the use of a lined manure storage facility; the vast majority either spread manure daily or stored their manure in the barn or in an unlined pile or storage basin outside.

In general, **dairy farms were more likely to have adopted recommended practices than other types of farms**. Dairy farmers are much more likely than other livestock farms to use a lined manure storage structure (25 percent versus 10 percent), and larger dairy operations are much more likely to have lined storage facilities than smaller dairy operations. Because of their typically larger scale of operation, Wisconsin dairy farms have greater capital and managerial resources to devote to

manure management and environmental protection than do operators of other types of livestock farms. This is particularly true when investments in physical structures are considered. However, even among those dairy farms that use such storage structures, one-fifth still spread manure daily, which reduces the potential environmental benefits of the structure. Overall, only 20 percent of dairy operations follow both the recommended practices of manure storage and spring or fall hauling.

The greater concentration of livestock on dairy farms and the more intensive use of feeds and nutrients imported to the farm also suggest that dairy farms may have a greater potential for environmental problems associated with manure and nutrient management. As such, they are more likely to require better management skills and costly storage structures to handle their manure. Unlike popular perceptions of large scale dairying, however, **the evidence from our survey does not support the argument that larger dairy herds are necessarily worse environmental actors**, at least at present. Rather, while larger herds do present greater challenges in terms of manure management (that is, the risk of environmental contamination is probably higher on farms with larger herds due to increased concentrations of animals), these larger farms are also more likely to be using recommended manure storage and handling practices. In addition, there does not appear to be a strong connection between the size of a dairy herd and the number of cropland acres available per dairy cow. Thus, at least to this point, larger dairy farms appear to be no more likely than smaller farms to have land shortages that would result in potential nutrient loading problems.

Interestingly, more than half of the dairy farm operators who responded to our questionnaire reported that they expect to leave dairy farming within the next five years. While our past research suggests that intentions to leave are an imperfect predictor of actual exits, such operators are likely to have shorter planning horizons, which could discourage them from making major investments in storage facilities and equipment for manure management. Because expectations are influenced by herd size and the age of the operator, it is difficult to ascertain whether they have an independent effect on manure management behavior.[16]

Regardless of herd size, the vast majority of dairy farm operations spread their manure on fields that are within five minutes of the barn by tractor. The concentration of manure in a limited area can increase the potential for nutrient loading and the likelihood of water contamination from nitrogen leaching or phosphorus runoff, though our data were insufficient to document any actual environmental impacts.

Meanwhile, larger dairy herds were much more likely to have concrete barnyard surfaces and somewhat more likely to have engineered filter strips to handle barnyard runoff than were smaller dairy operations or operators of other kinds of livestock farms. Most livestock yards in Wisconsin drain into adjoining fields.

Finally, it is clear that although farmers are quite concerned about possible overregulation from state and federal agencies dealing with manure and nutrient management issues, the vast majority of farmers in our sample did not feel that current regulations were difficult to meet. Similarly, a very small number reported having received complaints from neighbors about noise, odors, or flies from their farming operations.

Why don't more Wisconsin livestock farmers follow recommended manure management practices?

Scientists and others working to develop environmentally friendly manure management systems may be frustrated by the fact that most Wisconsin livestock farmers do not utilize recommended practices which, if followed, could significantly improve the environmental performance of livestock agriculture. Although our survey did not explicitly ask farmers to list the reasons behind their decisions regarding specific manure management practices, we can still offer some important suggestions for why most farmers continue to spread manure on a daily basis, and why they have tended not to invest in lined manure storage facilities. Arriving at a better understanding of farmer behavior is vital to providing direction for future research and extension programs.

The role of farmer motivation and knowledge

It is commonly believed that some of the biggest obstacles to the use of improved manure management practices relate to motivation and knowledge gaps on the part of producers (Rogers, 1995). If farmers don't care to change their practices, or if

they are unaware of the consequences of their present management practices and the available alternatives, they cannot be expected to adopt recommended practices.

The results of this study suggest that Wisconsin farmers are more aware of environmental concerns than is often appreciated. Almost all of the respondents agreed that manure management is a critical issue in the industry, that farmers must do a better job of protecting the environment, and that there is room for improvement. Farmers feel that environmentalists often fail to understand the complexities of farming, and that efforts to "fix" the problem should be accompanied by public subsidies to absorb the private costs of changing management practices, especially when few of the social benefits are realized by the producers themselves.

The degree to which farmers in our study felt personally responsible for water quality impacts is less clear. The responses to survey questions indicated that most farmers felt that "large scale" livestock production was a particular threat to environmental quality, but we did not ask specifically about whether or not farmers were concerned about environmental impacts *from their own farm operation*.[17] The survey also did not ask whether farmers were fully aware of the technical and managerial options available to them to reduce potential nutrient leaching or runoff. Since awareness of alternatives is a critical precondition to changing behavior, this topic should be a priority in future research.

The links between concern for the environment, awareness of the impacts of different practices, and changes in behavior are also complicated by the fact that environmental performance is only one of a complex set of goals that farm decision-makers attempt to pursue. Certainly, farms are first and foremost business enterprises, with imperatives to generate a reasonable return on investments. In addition, since almost all farms in Wisconsin rely principally on family labor, the lifestyle aspirations, consumption needs, capabilities and labor schedules of family members can constrain the ability of farm operators to pursue practices that are optimal from either an economic or an environmental perspective.

The "fit" between manure management practices and Wisconsin livestock operations

Although farmer attitudes and concerns influence their behavior, it is also likely that technologies and management practices that have been promoted by university and extension staff may not be equally successful on all types and sizes of farm operations. Indeed, the compatibility of new agricultural technologies with the existing farm management, land, labor and capital resources is a prime determinant of adoption patterns (Nowak, 1987; Swanson et al., 1986).

As discussed above, the most consistent pattern we observed in the survey responses was the fact that larger farms (and in particular, larger dairy farms) were much more likely to have improved manure storage structures and barnyards. Dairy farms milking more than 100 cows were almost twice as likely to have lined storage facilities as farms with herds with between 50 and 99 cows, and 10 times more likely than herds with less than 25 cows. It is apparent that the increased use of lined manure storage and handling facilities on bigger dairy farms stems from economies of scale that make them more cost effective on larger operations (Holmes and Klemme, 1989). Frame (1994, 1997) looked at the costs of construction and associated barnyards for installing a manure storage system in Trempealeau and Door counties, Wisconsin, and found that these costs average $63,592 and $66,060, respectively—without considering the expenses for associated additional equipment and repairs that most farmers also purchase. Although a manure storage system does serve to defray costs by preserving nutrients that would otherwise be lost, "even the maximum nutrient values will not completely cover the annual costs of any long-term storage system for a 60-cow herd" (Holmes and Klemme 1989: 208). Given this, even when public dollars are available to subsidize the construction of manure storage facilities, we expect that larger operations will continue to be more likely than smaller ones to invest in such structures.

Also, it may not make sense for operators nearing the end of their careers to invest the time and money it would take to achieve optimal environmental performance, because significant capital investments in manure storage facilities are likely to have relatively long pay-back periods. As reported earlier, a surprisingly high number of Wisconsin dairy farm operators report intentions to exit farming in the next three to five years (see Table 2). Given that most of them do not have lined facilities now, it seems unlikely that they will choose to invest in them given these short time horizons.

Meanwhile, in a variety of informal discussions with farmers, we have frequently heard that improved manure management is also constrained by the seasonal labor bottlenecks associated with diversified livestock-crop production on family-labor farms. It is particularly difficult to find time to spread large volumes of manure in the spring, when farmers are already working long hours preparing and planting fields for the summer growing season. Since most farmers have come to think of manure management as a waste disposal problem, rather than as a nutrient management activity, it is also an activity that is easily delegated to family members and done in small installments on a daily basis without a great deal of careful planning.

What should be done? Implications for future research and extension

Much of the research and extension work on manure management in Wisconsin over the last 10 years has focused on a "package" of technological and managerial practices that are thought to both increase economic returns to farmers (by more effectively utilizing the nutrients present in manure) and to minimize the potential for environmental impacts related to nutrient leaching and runoff. Key elements of this "improved" manure management approach involve storing manures for extended periods of time (preferably in lined facilities), incorporating manures into the soil shortly after spreading on crop fields (usually in the spring or fall), and reducing commercial fertilizer applications based on "credits" for the estimated nutrient content of the manure.

The results of the 1995 Wisconsin Farmer Poll suggest that the key aspects of this package have yet to be adopted by a majority of livestock operators. Most farmers have no long-term manure storage facilities, and they spread manure daily or frequently. Moreover, previous research has also shown that a minority of Wisconsin farmers take appropriate credits for the nutrient content of the manure they do spread on their fields (Nowak et al., 1996). Among our sample farms, the best predictor of adoption appears to be the scale of farm enterprise, with dairy farms milking more than 100 cows the most likely to be using at least some of the recommended practices.

The limited success of efforts to develop and promote improved manure management in Wisconsin suggest that the time is ripe to do a more comprehensive analysis of the reasons why farmers manage manure they ways they do. This would involve both qualitative and quantitative research efforts designed to identify the key barriers to using improved manure and nutrient management practices. Specifically, a better understanding of the complex interrelationships between manure management and other farming activities (cropping, labor patterns, etc.) will help researchers design more holistic solutions. Preliminary evidence from this and previous studies suggests that a combination of economic, sociological, and biophysical factors are all going to be important.

In addition, repeated surveys of farmers over the last 5 years have indicated that the moderate-scale, family-labor dairy farm is likely to remain a major portion of the Wisconsin dairy industry for the foreseeable future (see Barham et al., 1995; Jackson-Smith and Barham, 1996; Jackson-Smith, 1996). The results discussed above suggest that this group is unlikely to adopt most of the package of currently recommended manure management practices. As long as we rely on voluntary adoption to accomplish our environmental goals, future research and extension work will need to be redirected toward adapting current technologies to address farmers' concerns, or developing entirely new approaches that better fit typical Wisconsin livestock farms (see discussion in Powell, 1995). Assuming that most operators will *not* have improved storage facilities and will therefore haul manure daily or frequently, efforts can be directed toward solutions that work within this paradigm.

One way to ensure that future innovations will be more widely utilized would be to involve farmers more directly in the technology development process itself. Producers could be included in efforts to identify research objectives, shape the design of experiments, and evaluate various manure management technologies or practices. Efforts to conduct experiments and demonstrations on actual farms are an important step in this process, provided the farms are representative of those in the industry and that the lessons learned are conveyed back to the scientific community.

Finally, we know that there is considerable variation in the practices farmers use, and scientists tell us that the unique physical characteristics of a particular farm (or farm field) will have a significant impact on whether or not a particular practice will actually lead to an environmental problem. Some have suggested that a relatively small proportion of the livestock industry in Wisconsin is probably responsible for a disproportionate amount of the environmental impacts (Nowak, 1997). It seems appropriate to increase our understanding of precisely what combinations of farm practices and biophysical environments are likely to produce the worst environmental outcomes, and to target our research and extension efforts at these critical actors. This would mean moving away from cookbook solutions that are applied statewide, toward more site specific intervention activities.

Endnotes

[1] Perhaps the best effort to date has been the work of Nowak et al. (1996), who have provided a detailed profile of manure and nutrient management behavior among Wisconsin farms located in several watersheds around the state. To the best of our knowledge, however, in recent years there has not been a study based on a statewide representative sample of farms focused on manure or nutrient management behaviors.

[2] It should be noted that the nutrient content of manure on any specific farm may vary considerably from the statewide averages used in calculating nutrient credit recommendations, so differences in manure and commercial fertilizer application rates must be interpreted with some caution.

[3] In January, 1997, ATFFI was renamed the Program on Agricultural Technology Studies (PATS).

[4] This situation can be contrasted with that in many western and southwestern states, where large dairy farms often forego crop production and purchase all of their feed requirements. On these feedlot-type dairies, environmentally sustainable options for manure disposal are more limited.

[5] It should be noted that our past research has shown that "plans to exit" are in fact a weak predictor of whether or not a farm actually exits (Jackson-Smith and Barham, 1996). Many of those who say they expect to quit in five years actually remain active dairy farmers well beyond that time.

[6] In recent years, there has been increased controversy as to the merits of the public policy focused primarily on constructing lined manrue storage facilities (Nowak et al., 1996). A sizeable group of scientists, extension educators, and regulators believe that it is possible to spread manure frequently throughout the year as long as it is applied to fields that have low soil nutrient test values, at points in the crop rotation when it can be readily utilized by plants, and when manure credits are used to reduce commercial fertilizer applications (Shelley, personal communication). Moreover, it is important to bear in mind that the environmental impacts of any particular practice on a given farm is dependent on the physical landscape conditions (soil types, topography, location within watersheds, etc.), climatic conditions (particularly extreme events), and the balance between livestock numbers and available farmland onto which manure might be incorporated. Recognizing these qualifications, the rest of this report will focus on the use of manure storage and daily hauling practices among Wisconsin livestock operators.

[7] Because these filter strips require significant investments that provide little in the way of direct financial returns to farmers, federal, state and local governments have provided cost-sharing dollars to help defray the costs of installing them. Hence, the use of such structures is likely to be higher in areas where these programs are available.

[8] It is possible that this item, in particular, was underreported by farmers in our study.

[9] The Wisconsin Department of Natural Resources requires a manure handling permit from operations having more than 1000 "animal units" (roughly equivalent to an 800 cow dairy).

[10] It is important to emphasize that the factors listed here represent potential risks of environmental impacts. To date, there has been little systematic research that would confirm or deny the link between larger dairy herds and increased nutrient losses to the environment.

[11] Acreage per cow was computed by taking the total acres of cropland operated (excluding all woodland, swampland, and land used for buildings and barnyards) and dividing that by the average size of the milking herd (excluding dry cows and heifers).

[12] The 1995 Wisconsin Dairy Farm Poll was conducted at the same time as the 1995 Wisconsin Farmer Poll, and received responses from almost 1,200 dairy farms. However, because the questionnaire used in the Dairy Farm Poll did not ask about manure management practices, the results are not used elsewhere in this report. For a

summary of the results of the 1995 Dairy Poll, please contact the Program on Agricultural Technology Studies, UW-Madison.

[13] The degree to which this is explained by the fact that larger farms tend to have more acreage—and thus more fields located five or more minutes from the barn—cannot be evaluated from our data. Moreover, depending on topography, machinery, and the layout of each individual farm, it is possible to travel fairly large distances in 5 minutes on many Wisconsin farms.

[14] Storage structures may be designed to hold manure for only relatively short periods of time (1-3 months) or for as much as 12 months. As a result, the presence of such a structure will not necessarily preclude frequent or daily hauling during many times of the year.

[15] Excessive relative to the nutrient demands of crops grown on those fields.

[16] In a separate analysis (not reported here), we developed a multivariate logistic regression model for predicting the use of a lined manure storage facility among dairy farms. The model (which was only moderately successful at predicting storage facilities) suggested that herd size is the single most important factor, and that the influence of age and expectations is relatively unimportant once herd size is controlled for.

[17] Sociological research elsewhere has demonstrated that general concerns do not always translate into personal responsibility for the problem. Indeed, on other items on the 1995 questionnaire concerning groundwater pollution from nitrogen fertilizers, the proportion of farmers that felt it was a "serious problem" on their own farm (5 percent) was much smaller than the percent that felt it was a serious problem in their county (20 percent) or state (30 percent).

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