Sustainability of Management-intensive Grazing Dairy Farms versus Conventional Confinement Dairy Farms

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Abstract: Goals on agricultural sustainability have been articulated in the publication "Towards Sustainable Agricultural Systems in the 21st Century" (National Research Council). These goals include: 1. Farms must be profitable. 2. Farms must enhance environmental quality. 3. Farms must increase the quality of life for farmers and society. 4. Farms must produce enough to satisfy human needs. University of Maryland research has indicated that management-intensive grazing (MIG) dairy farms may achieve these goals better than conventional confinement (CC) dairy farms. Financial data collected from dairy farms indicates that MIG farms were more profitable than CC farms on a per cow, per milk-weight, and per acre basis for farms with less than 200 cows (Hanson, et.al. 2013). Profits of MIG farms were also less variable, so that MIG farms faced less income risk. Grazing has other benefits as well. Grazing seems to be much healthier for dairy cows. Veterinary, breeding, and medicine costs are much less for pastured cows than confined cows. Because they are healthier, grazed cows can be milked longer and or culled less frequently. As a result, MIG farms have a larger number of higher quality animals for sale (for example, bred heifers). MIG farms are also less labor intensive. Less time is spent in crop production, feeding, and manure management. Costs of hired labor are thus lower in MIG farms than in CC farms. Other University of Maryland research addressed the environmental impacts of grazing (Weil, R.R. & Gilker, R.E.). This research found no evidence of excessive nitrogen leaching from the MIG watersheds. Neither N nor P concentrations were increased as stream water flowed through well managed MIG pastures. The benefits of grazing may extend beyond the farm itself, as the conversion of cropland to permanent grass may have implications for global warming and soil conservation, as well as quality of life for surrounding communities. As suburban development continues to encroach on farmland, and dairy farming becomes more economically challenging, MIG provides an alternative that can be both environmentally friendly and financial viable.

Keywords: Management-intensive grazing, dairy, sustainability

Introduction

This paper summarizes two research projects conducted by the University of Maryland comparing conventional confinement (CC) farms and management-intensive grazing (MIG) farms in terms of profitability and environment impact and suggests that MIG productions methods may be more sustainable than CC production systems.

CC dairy farming in the United States is capital-intensive, using methods that confine large herds of highly productive dairy cows to a small part of the farm while practicing high-input crop production on most of the land. Large machines harvest and process crops into feed and bring this feed to the cows while other machines haul the cow manure to the fields to fertilize the soil. Bringing a high-nutrient diet right to the cow allows the animal to use more energy for producing milk rather than expending energy foraging for food and walking to and from the milking parlor. This system generates high milk productivity per cow. However, the costs in terms of money, resource use, and environmental impact are high for such activities as producing crops, hauling feed, purchasing feed concentrates, managing manure, and providing veterinary care to keep cows healthy under crowded conditions. In addition, high production levels keep milk prices low, which, in combination with high production costs, keep profit margins thin for most dairy farmers. When farmers milk more cows than can be maintained with the feed produced on the farm itself, additional feed must be purchased and imported onto the farm to maintain the herd. The imported feed brings with it large amounts of nitrogen (N) and phosphorus (P). Cows excrete 60-85% of the nutrients ingested, although efforts to fine tune animal diets may somewhat reduce the excretion of N and P. Eventually the herd supplies more manure N and P than the farm fields can properly assimilate. The resulting build-up of N and P increases the potential for nutrient loss that can lead to pollution of ground and surface waters.

MIG is a very different approach to dairy production. On a MIG dairy farm, portable electric fencing is used to subdivide pastures in to paddocks. Cows are moved to a fresh paddock once or twice a day. During the growing season, grazed forage is the primary source of protein and energy for the cows, eliminating the need for feed crop production and its expensive, energy-demanding infrastructure. By grazing, the cows harvest the feed and spread the manure, rather than machines. Because the grazing lifestyle is less stressful on cows, veterinary bills are substantially lower than for confined animals. Although a cow under MIG typically produces less milk than one under confined feeding, it requires far less expense to maintain. Research in Maryland and other states indicates that both profitability and life-style quality can rise dramatically for dairy farmers who successfully switch production methods.

Economic comparison of management-intensive grazing and conventional confinement farms

University of Maryland analyzed MIG and CC dairy farms and compared profitability on a per cow, per milk weight, per acre, and per farm basis including a risk analysis. (Hanson, et.al. 2013). Space limitation of this paper only permit a summary of the per cow, per farm and risk analysis portion of the research. Those interested in the rest of the analysis are encouraged to read the above journal article.

Explanation of participating farms and analysis methodology

Since 1995, Johnson has collected tax data on income, expense, and profit from 62 dairy farms (not all 62 farms participated each year). Observations were pooled across years 1995-2009, creating a data set of 556 observations. Financial variables were adjusted for inflation with the Consumer Price Index for the United States northeast region. The farms in this study were those who voluntarily participated. Comparisons with data from the Census of Agriculture for the years overlapping with the farms used in the study indicated that they were reasonably representative of the Maryland dairy farms in general. Of the 62 farms, 14 were MIG farms and 43 were CC

farms. The other 5 farms switched from CC to MIG systems during the sample period. In this study, MIG farms were defined as those whose herd rations included at least 30% dry matter from pasture for a minimum of 4 months which is also the requirement for organic certification. All of the farmers included in this study lay on the smaller end of the dairy herd size spectrum. However, CC farms were larger farms than MIG farms, with herd sizes 20% larger on average. CC farms also had more land than MIG farms. Not surprisingly, MIG farms had more pasture acreage and less crop acreage than CC farms, both in total and on a per cow basis.

Systematic differences in income and expenses between MIG and CC farms were analyzed using analysis of variance (ANOVA) with fixed effects for MIG versus CC farm and year, with the latter used to control for systematic differences across years due to weather, market conditions, and technological trends during the study period. Separate models were estimated for milk production, profit, each category of sales, and each category of expenses. Each model contained fixed effects for type of operation (MIG versus CC) and year. Formally, the model estimated for response variable Y on farm k in year t was $Ykt = a + bIkt + ct + ekt$ where Ikt is a fixed effect for type of operation, ct a fixed effect for year, and ekt a random error. An alternative specification using year-specific random effects yields results virtually identical to those reported here. This procedure adjusts for year-to-year variations due to weather, short-run price fluctuations, and similar factors.

The profitability of MIG and CC farms were compared on a per cow basis. Evaluating income and expenses per unit of production is a common method of assessing profitability. It allows an evaluation of competitiveness, because the number of cows is often a limiting resource and putting costs and returns on a per cow basis allows adjustment for scale of operation according to herd size. Output was measured in terms of both milk production (measured by weight) alone and in terms of revenue; the latter includes sales of crops and cattle as well as adjusting milk production for quality, as indicated by price. Income from MIG and CC farms was then compared on a whole farm basis in order to assess how well these two production systems perform in generating household farm income.

The relative riskiness of returns for MIG and CC farms was compared by estimating the standard deviations of profit over the sample period for each MIG and CC farm. Separate ANOVA models for the means and standard deviations of profit in MIG and CC farms were estimated using farm-specific fixed effects, which were used to adjust for the influence of operator managerial ability, land quality, asset composition, and other unobservables that remain constant over time. These estimated means and standard deviations were used to compute 75% lower confidence limits of profit as a measure of risk-adjusted income. Any difference in these lower bounds reflects a systematic difference in income risk that is directly attributable to the nature of CC and MIG dairy systems. The profit level attained at least 75% of the time by each system was calculated as $Li = Ei - KSi$, where Ei is average annual profit under production system i, Si is the standard deviation of profit under production system i, and $K = 0.577$ is calculated using a one-sided Chebyshev inequality.

Results of the analysis - profitability per cow

Herd size is the standard measure of scale in dairy farms. Farms at a disadvantage in terms of cost and profit per weight of milk produced may be able to compensate by expanding their scale of operation, i.e., by increasing herd size. As noted above, CC farms in our sample were larger on average than MIG farms. That greater scale of operation might make up for lower revenues, higher costs, and lower profits per weight of milk produced.

Milk production was 31% higher on CC farms than MIG farms (Table 1). As a result, gross income per cow was 25% higher for the CC farms than for MIG farms. MIG farms, however, had higher cattle sales per cow than CC farms. Cows that are grazed have a longer productive life

and the annual culling percentage for the herd is lower. As a result, MIG farms sell more higher-value bred heifers and young stock in contrast to CC farms that sell more lower value culled milk cows (White et al., 2002).

Table 1. Average annual values per cow for MIG and CC dairy farms, 1995 to 2009.[1]

	MIG	CC	Difference
Milk production (kilograms/cow)	6,532	8,528	1,996***
Income in dollars per cow			
Milk sales	2,752	3,443	691***
Crop sales	12	49	38***
Cattle sales	240	206	-34**
Other income	143	221	78***
Gross income per cow	3,147	3,920	774***
Expenses in dollars per cow			
Car and truck	7	8	1
Chemical	22	96	73***
Conservation	2	3	1
Custom hire	60	115	55***
Depreciation	362	347	-15
Purchased feed	809	1,045	236***
Fertilizer	69	120	51***
Freight and trucking	82	136	54***
Fuel	67	86	19***
Insurance	31	54	23***
Interest	120	132	11
Labor	66	193	127***
Rent or lease	168	174	6
Repairs and maintenance	175	270	95***
Seed	67	79	12*
Supplies	161	156	-5
Taxes	22	28	5*
Utilities	78	87	10***
Veterinary, breeding, and medicine	81	179	98***
Other expenses	60	139	78***
Total expenses per cow	2,511	3,456	946***
Profit in dollars per cow	636	464	-172***

*, **, *** shows significance at the 10%, 5%, and 1% levels, respectively.

[1]Income and expenses are expressed in CPI - adjusted dollars

Higher milk production per cow in CC farms came at a cost. Nearly every category of expense was higher for CC farms than for MIG farms. The only exceptions to this were depreciation and supplies expenses which were statistically insignificant. One obvious source of greater expense was purchased feed. Other large differences occurred with labor, veterinary, breeding, medicine, and repair expenses. These expenses accounted for almost 60% of the $946 difference in total expenses between these two production systems.

Nearly all the CC farms in this study used Holstein cows. Holsteins are a heavier breed than the Jerseys and cross breeds used by MIG farms. Holsteins produce more milk and thus require more feed. Additionally, confined cows consume feed with a lower moisture content than grazed cows

feeding on high moisture pasture and thus confined cows consume more feed and are accordingly able to produce more milk.

Hired labor expenses per cow in CC farms were roughly three times those in MIG farms ($193/cow versus $66/cow). Dairy farmers, in general, have high labor requirements due to the need to milk twice or three times a day, feed cows, clean the barn, haul manure, and complete field work. One advantage of grazing is that the farmers can reduce the time required for feeding, barn cleaning, manure hauling, and field work. The cows spend less time in the barn, spread their own manure, and feed themselves. White et al. (2001) found that 85% of defecations and urinations occur in the pasture for the grazing herd, greatly reducing the amount of manure to be handled in the barn. This reduced labor requirement allows MIG farms to rely relatively more on unpaid family labor and less on paid hired labor than the CC farms.

Veterinary, breeding, and medicine costs per cow in MIG farms were less than half those in CC farms ($81/cow versus $179/cow). A strong argument can be made that grazing is healthier for a cow than being confined. For example, Washburn et al. (2002) found that pastured dairy cows had significantly less incidences of mastitis than those dairy cows in the CC system while the CC herd also had significantly more cows culled because of mastitis problems than the grazing herd.

While CC farms had higher gross income per cow, they also had higher total expenses per cow. As a result, the CC farmers had less profit per cow than MIG farms.

Results of the analysis - profitability per farm and profitability risk

The bottom line for dairy farms is how well they perform in generating a livable income for the farm families that operate them. The relative performance of MIG and CC farms on a whole farm basis was similar to their relative performance per cow. CC farms produced more milk (894,664 kilogram cwt versus 540138 kilograms) and had higher gross income than MIG farms ($414,048 versus $260,298) (Table 2). CC farms also had higher total expenses. Overall, MIG and CC farms generated statistically similar average incomes. While both MIG and CC farms generated roughly the same levels of income, CC farms were noticeably riskier as measured by standard deviation (Table 2). As a result, the level of income met or exceeded three out of every four years was roughly 40% higher on MIG farms than CC farms. Thus, MIG farms appear to be a more consistent source of household income than confinement systems.

Table 2. Average annual values per farm for MIG and CC dairy farms, 1995 to 2009.[1]

	MIG	CC	Difference
Milk production (kilos/farm)	540,138	894,802	354,664***
Gross income per farm	260,298	414,048	153,750***
Total expenses per farm	206,914	366,211	159,307***
Profit in dollars per farm	53,383	47,826	-5,557
Profit standard deviation	32,055	38,136	
75% Lower confidence level	36,405	26,075	

*** shows significance at the 1%.

[1]Income and expenses are expressed in CPI - adjusted dollars

75% lower confidence limit indicates the profit attained in three out of every four years.

The foregoing comparisons indicate that MIG farms exhibited financial performance better than that of CC farms in the Maryland region, at least for dairy farms of the relatively small sizes included in our sample. MIG farms produced less milk but incurred substantially lower costs. MIG farms were more profitable than CC farms per weight of milk produced and per cow and were no less profitable on a whole farm basis (i.e., once size of operation was taken into account). Lower up front expenditures made MIG farms less vulnerable to fluctuations in market conditions, weather, and other factors beyond farmers' individual control. As a result, income was less risky in MIG farms than in CC farms. These financial performance measures suggest that MIG systems may offer a way for small farms to compete in dairy production.

MIG systems may also enhance the sustainability of small dairy farms by allowing entry of larger numbers of young farmers. MIG farms require less equipment for crop production and smaller sizes of the free stall area in barns (since cows spend more of their time grazing in pasture). Lower upfront investment costs make them easier to finance and thus more accessible to new entrants lacking capital.

MIG systems are still relatively new, suggesting that there is likely considerable room for improvement. Innovations will likely be site specific, as researchers and farmers adjust grazing practices to suit soils and climate; on-farm learning by doing and experimentation are likely to play important roles in this process. Breeding of animals and plant varieties better adapted to intensive grazing can also help increase productivity in MIG systems. As these innovations are developed, the advantages of MIG systems over CC farms are likely to grow.

Agricultural commodity prices have been becoming more volatile. Increased demand due to economic growth in developing countries and to the growth of biofuel uses has made commodity markets more susceptible to fluctuations in production. Decreased reliance on purchased feed and lower upfront expenditures make MIG systems less vulnerable to volatility in commodity prices. Lower risk is thus likely to become an increasingly important advantage of MIG systems.

Milk produced in MIG farms has several attributes that command higher prices today and seem likely to continue to do so in the future. Some MIG farmers have become organically certified. The transition to organic production is not as difficult when beginning from a MIG base. Some consumers are willing to pay more for livestock products from farms that provide greater animal welfare. MIG farms can be seen as a more natural, cow friendly form of dairying. Lower veterinary expenses per cow, longer milking lifespans (or fewer frequencies of culling), and higher values of cow for sale (for example, higher quality bred heifers) all indicate that cows are healthier in MIG systems than CC systems. It may thus be possible to market milk from MIG producers as an enhanced animal welfare product with a premium price.

In many areas, environmental regulations are likely to target agricultural farms that have heretofore been largely exempt from them. For example, new water quality regulations affecting the Chesapeake Bay watershed, where the dairy farms in this study are located, are likely to require reductions in runoff of nitrogen and phosphorus from smaller agricultural farms similar to those current effluent discharge regulations impose on large confined animal feeding farms. MIG farms have lower nutrient runoff than CC farms and will thus likely incur lower compliance costs if and when new, stricter regulations are implemented.

Land requirements likely impose the principal limitation on the size of MIG farms. On the east coast of the United States, for instance, grazing farms need 1.5 to 2.0 acres of pasture for every dairy cow/calf equivalent to provide sufficient grass to support a dairy operation. Pasture land for MIG operators must be contiguous to the milking parlor and located no farther than a cow can walk to and from twice a day. That requirement limits the maximum size of a MIG farms. A lack of contiguous pasture land near their farms may create an absolute barrier to expanding the

size of grazing farms to levels below that maximum as well. And in areas where land prices are high, as they are in much of the east coast of the United States, expansion of grazing farms beyond the 200-cow size seen in this study may not be economically justifiable.

Enhancing Environmental Quality through MIG

The MIG approach also offers potential environmental benefits which will contribute to the sustainability of dairy farms. Land on MIG farms is nearly all permanently covered by grass, which improves soil quality and greatly reduces sediment losses compared to cropped fields. Furthermore, soils under pasture accumulate organic matter, a process that not only improves the soil, but also removes carbon dioxide from the atmosphere. Converting cropland to pasture on MIG farms may therefore help counter worrisome changes in the global climate caused by the build-up of carbon dioxide in the atmosphere. Because less feed is imported onto MIG farms, this could result in less potential for pollution from excess nutrient accumulation.

Scientists know little about the impacts of the MIG pastures on nutrient losses to ground water and surface water. Research was initiated in Maryland to determine whether MIG could be an environmental benefit for dairy farmers. Weil & Gilker, in collaboration with the USDA/ARS Pasture Lab in Pennsylvania, studied the environmental performance of three well-managed farms in central Maryland - two MIG farms and one CC farm. The project involved six watersheds, two on each farm. Water was sampled in two streams running through two of the MIG farmsheds. Groundwater under both pastures and manured cornfields was sampled regularly using 64 piezometers (special monitoring wells that allow sampling the upper meter of groundwater) installed at three or four depths in nests, with three nests of piezometers in each watershed. The groundwater was sampled biweekly from the piezometers and surface water was also sampled biweekly. All samples were analyzed for both nitrogen and phosphorus. Groundwater samples from the grazed watersheds had average nitrate concentrations of 4.4 ppm, significantly lower than the average of 8.9 ppm nitrate-N found in groundwater samples from the confined farm watersheds. The EPA water quality standard for nitrate-N is 10 ppm.

Dissolved reactive P concentrations from all six watersheds were well above the surface water critical level of 0.01 to 0.02 ppm. Averages of phosphate-P on the neighboring MIG and CC farms were 0.15 and 0.14 ppm. The MIG watershed was downhill from where they previously stored manure, and was consistently found to have high levels of P in groundwater. That watershed seemed to be showing historic influence rather than impacts of current management. Concentrations of phosphate-P on the second MIG farm were significantly lower, averaging only 0.03 ppm, possibly due to immobilization of phosphorous by the calcareous geological material underlying that farm. The surface water monitored in two watersheds on one of the MIG farms was generally within acceptable limits for N during both base and storm flow. Total inorganic N was consistently less than 4 ppm, with approximately 1/3 ammonium and 2/3 nitrate. Stream water N concentrations were lower during storm flow than base flow, suggesting dilution with low N surface runoff. Significantly, there was no evidence that streamwater N concentration increased as the streams flowed through the grazed watershed. Streamwater total dissolved P concentrations were near the 0.1 ppm level of total P considered critical for eutrophication, although there were significantly higher levels of P during storm flows. Phosphorus concentrations did not increase as the stream flowed across the grazed watersheds, with the exception of 1 stream during storm flow early in the study. In that stream, P became elevated apparently because during the winter dry cows “camped” there, trampled the grass, had some access to the stream, and were fed on hay (which imported nutrients into the area). Because the farmer subsequently changed his management of this area, there was little increase in stream water P thereafter. Conclusions of this study are as follows:

- There is no evidence of excessive nitrogen leaching from the MIG watersheds.
- Phosphorus levels in groundwater seemed related to geologic soil parent materials and were low regardless of farm management system.
- Neither N nor P concentrations were increased as stream water flowed through well-managed MIG pastures.
- Under appropriate management, grazing appears to engender relatively low risks for nutrient pollution.
- The benefits of grazing may extend beyond the farm itself, as the conversion of cropland to permanent grass may have implications for global warming and soil conservation, as well as quality of life for surrounding communities. As suburban development continues to encroach on farmland, and dairy farming becomes more economically challenging, MIG provides an alternative that can be both environmentally friendly and financially viable.

These two research project conducted by the University of Maryland provide evidence that management-intensive grazing may help accomplish the four goals of agricultural sustainability including; profitability, environmental quality, increased quality of life for farmers and society, and producing enough to satisfy human needs.

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