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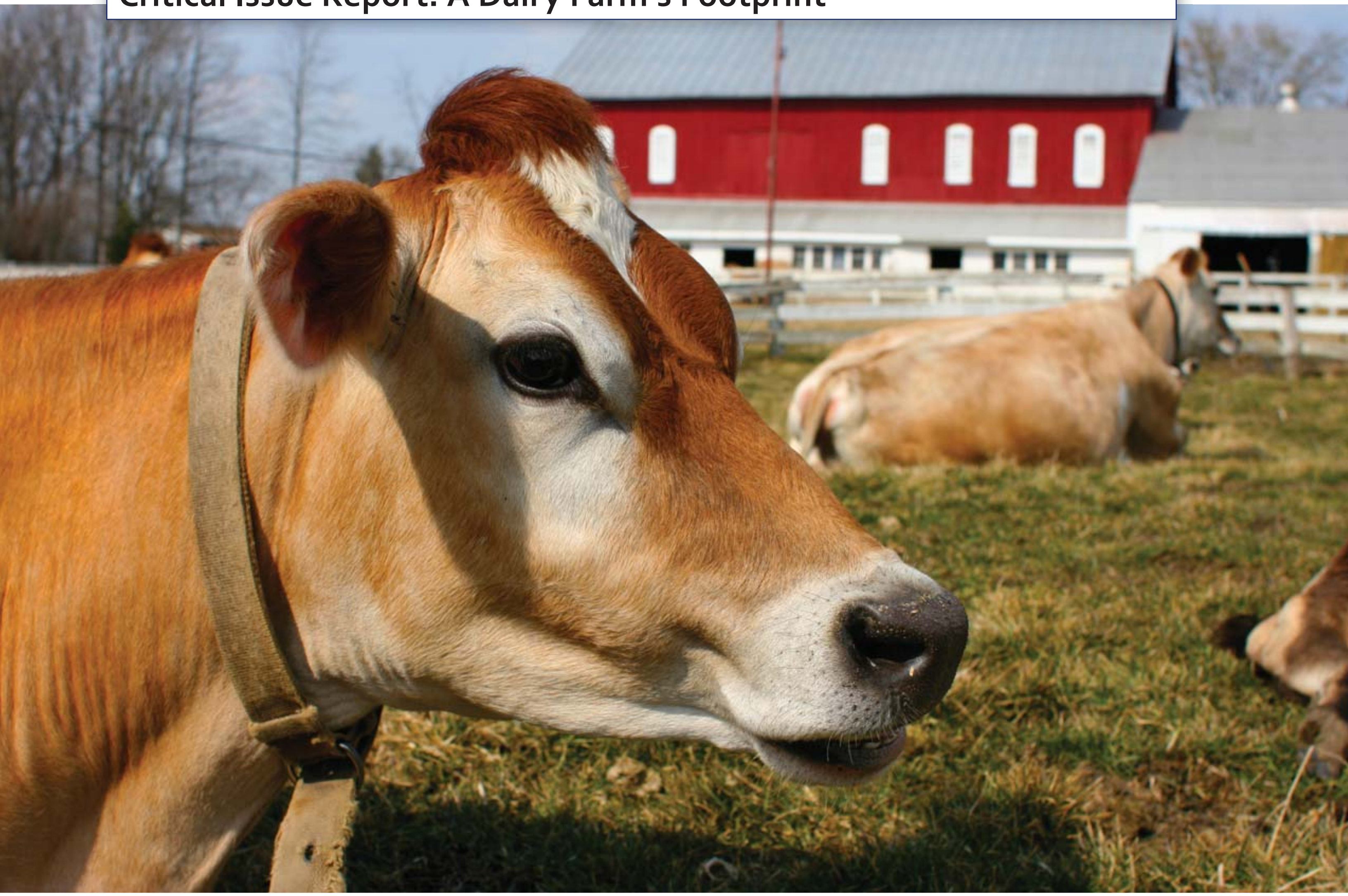
Critical Issue Report: A Dairy Farm's Footprint



A Dairy Farm's Footprint:
Evaluating the Impacts of Conventional and Organic Farming Systems

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Preface

Dairy farming systems impact the environment, animal well-being, and the nutritional quality and safety of milk and dairy products in many ways. Many private companies and organizations are developing new sustainability indicators encompassing energy and chemical use in the dairy sector, as well as system impacts on net greenhouse gas and nitrogen emissions.

The Organic Center's initial work on the environmental impacts of dairy production focused on land use and the pounds of pesticides, animal drugs, and synthetic nitrogen fertilizer not used on organic dairy farms. A Critical Issue Report was released in March, 2009 entitled *Shades of Green: Quantifying the Benefits of Organic Dairy Production* (access this report at http://www.organic-center.org/science.environment.php?action=view&report_id=139.

Over the last 18 months, the "Shades of Green" (SOG) dairy sector calculator has been significantly expanded and refined. Concurrent with the release of this report, the Center is making available free of charge via its website SOG Version 1.1, as well as a 92-page report documenting all the equations in SOG Version 1.1 and providing step-by-step instructions for people wanting to use the SOG calculator.

The Center is, to our knowledge, the first organization to release a fully operational version of a dairy sector environmental footprint model, along with a comprehensive document on the structure, potential applications, and equations embedded in the model. While such full disclosure will not end debate on the structure or equations in SOG, it will help focus ongoing discussion on the science and key data inputs, rather than speculation regarding what the SOG model actually entails.

The SOG calculator is a work in progress. New modules will be added in the next year encompassing other greenhouse gas emissions, total Global Warming Potential, animal drug use, and soil carbon sequestration. New applications are also planned for the near future, beginning with the modeling of typical conventional and organic dairy farms by region.

The SOG calculator offers farmers, researchers, the food industry, and policy makers an opportunity to expand the focus and sharpen the resolution of dairy sector environmental footprint studies. SOG Version 1.1 encompasses most of the critical impacts of dairy farm management systems on milk quality and safety and on cow health, areas of impact likely to remain high on the agenda of consumers wanting to support with their food dollars constructive change down on the farm.

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Acknowledgements

The Center deeply appreciates the assistance of the team of dairy scientists, industry specialists, and researchers that have worked with the Center in developing SOG Version 1.1 and applying it in the "Conventional and Organic Farm Environmental Footprint" (COFEF) application of SOG Version 1.1 . Team members and co-authors of this report include:

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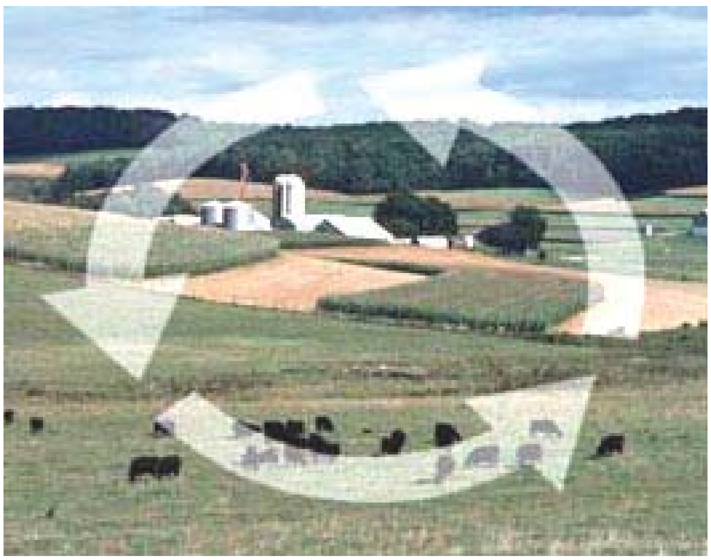
Special recognition is warranted to two consultants working for the Center. Cory Carman helped throughout with the design of the calculator, and especially the projection of manure and methane emissions. Likewise, Karie Knoke, KComp Solutions of Sandpoint, Idaho, has done an excellent job in creating within Microsoft Excel a powerful and flexible, yet user-friendly analytical tool. Karie also helped shape several enhancements that make the SOG calculator easier to use and understand. Thanks also to Karen Benbrook for desktop publishing this report and the SOG user's manual, as well as for the steady support and encouragement throughout the long process required to complete and release SOG Version 1.1, this first application and report.

The development of SOG and this application were made possible by a generous grant from the Packard Foundation. This grant has allowed the Center to begin a program of research on the contributions of organic farming systems to the mitigation of nitrogen pollution and greenhouse gas emissions. Clearly, that potential is significant and deserves far more recognition in the policy arena.

Funding from long-term supporters of The Organic Center has also helped finance work on the calculator and this report. Special thanks are due to Stonyfield Farm, Horizon Organic and WhiteWave Foods, Aurora Organic Dairy, and Organic Valley for encouragement and support as this project has unfolded over the last two years.

1. Summary

The environmental footprint left in the wake of milk production is composed of three clusters of impacts. Air quality and the atmosphere are affected by the volume of greenhouse gases (GHG) and nitrogen that are emitted relative to the volume that are sequestered in soil or otherwise captured or used. Water quality and aquatic ecosystems are impacted as a result of soil erosion and runoff containing fertilizer nutrients, pesticides, animal drugs, and pathogens. The soil and terrestrial ecosystems are altered as a result of land use, cropping practices, fertilizer and pesticide applications, and manure management.



Numerous studies conducted around the world have attempted to measure one or more aspects of the environmental footprint of dairy farming. One study concluded that high production, input-intensive dairy farm management systems leave a lighter footprint than organic dairy farms (Capper et al., 2008), while others reach the opposite conclusion (Haas et al., 2001; Arsenault et al., 2009). The different results reached by seemingly similar studies often result from how researchers draw boundaries around the factors or variables included and excluded in the analysis, how results are measured and reported, and decisions regarding the best equations and input variable values to use in model simulations.

A major greenhouse gas study by the Food and Agriculture Organization (FAO) of the U.N. claimed that livestock accounted for as much as 18% of global greenhouse gas emissions (Steinfeld et al., 2006). Recent work published by scientists lead by Dr. Frank Mitloehner at the University of California-Davis estimate that the true figure is closer to 3% (Pitesky et al., 2009).

Clearly, more accurate methods and models are needed to compare and contrast the performance of alternative dairy systems and to identify low-hanging fruit in the quest to lighten agriculture's overall environmental footprint. Toward this end, The Organic Center developed the "Shades of Green" (SOG) dairy farm management system calculator and applied it to four representative clusters of farms, two using conventional management and two organic systems. The four scenarios modeled are:

- Intensive Conventional Management with rbST Treatment, Holstein Cows
- Conventional Management, Holsteins
- Intensive Organic Management, Holsteins
- Pasture-based Organic Farm, Jersey Cows

Using the SOG calculator, the impacts of these four types of farms were quantified on milk and meat production and gross farm revenue, milk nutritional quality, land use, fertilizer and pesticide use, manure and nutrient wastes generated, and methane emissions. Unlike other studies, this analysis projects and takes into account the many effects of dairy farm management on animal health, reproductive performance, and longevity.

The equations and input variables embedded in the SOG calculator have been fully referenced in a lengthy "user manual" document released concurrently with this report (Benbrook et al., 2010; accessible free of charge at www.organic-center.org/SOG_Home). The major information sources relied upon in developing the calculator include dairy science journals, U. S. Department of Agriculture (USDA) reports, and GHG documents issued by the Environmental Protection Agency (EPA) or Intergovenmental Panel on Climate Change (IPCC).

In addition, the SOG calculator itself and all details and results from the current application of SOG to the above four scenarios are freely accessible via The Organic Center website (www.organic-center.org/SOG_Home) for anyone that wishes to better understand the model's structure and contents, or apply it to a given farm or set of farms.

A. Key Findings

Most Americans have heard the phrase "milk is milk" in dairy industry advertising and commentary. This claim, however, is hard to square with well-known facts. The safety of milk varies substantially across farms as a function of somatic cell counts in milk, residues of synthetic pesticides and animal drugs, and pathogens.

The nutritional quality of milk varies significantly as a result of differences in the levels of fat, protein, antioxidants, and heart-healthy fats including conjugated linoleic acid (CLA) and omega 3 (Butler et al., 2008; Ellis et al., 2006; O'Donnell et al., 2010). In fact, many dairy farmers are paid premiums for milk that is richer in fat and protein.

Farmers raising certain breeds of cattle, like Jerseys, routinely produce milk with one-third or more higher levels of fat, CLAs, and omega 3. Dairy cows allowed to obtain a significant share of their daily dry matter intake from pasture produce more nutrient-dense milk with markedly elevated heart-healthy fats (Butler et al., 2009). Milk nutrient levels are reduced on farms on which cows are pushed to produce beyond their genetic potential.

Because of the variability in milk nutritional quality, dairy scientists typically adjust milk production levels when reporting research results to reflect differences in fat and protein content, estimating what is known as "Energy Corrected Milk" (ECM). Studies that compare dairy farm performance on the basis of unadjusted milk production bias results in favor of Holstein cows and high-input systems and against certain breeds and dairy farms that provide lactating cows with access to high-quality, forage-based feeds and pasture.

The Holstein dairy cows on farms like those modeled in Scenario 1 produce 50% more milk on a daily basis than the Jerseys in Scenario 4, but only 22% more in terms of Energy Corrected Milk. ***Milk nutritional quality matters and must be taken into account in assessing a dairy farm's environmental footprint relative to milk production.***

Dairy animals contribute to the meat supply via milk and meat. Because lactating cows on organic farms produce through additional lactations, they give birth to more calves and produce more meat over their lifetime. The lighter-weight Jersey cows in Scenario 4 produce an estimated 2,700 pounds of meat over their lifetime, whereas the Holstein cows in Scenarios 1 and 2 produce 1,962 and 2,235 respectively.

In the quest to lighten dairy farming's environmental footprint and increase milk quality and safety, the most significant advantages of organic dairy farming arise from less stress on animals, improved animal health, fewer breeding problems, and longer productive lives, especially on well-managed organic farms utilizing high-quality forages and grazing for a significant share of dry matter intake.

Compared to milk cows on high-production dairy farms like those modeled in Scenario 1, lactating cows on organic dairy farms:

- Live 1.5 to two years longer,
- Milk through 4 or 4.5 lactations, in contrast to less than 2,
- Milk through shorter lactations averaging 313 to 337 days, instead of 410 days,
- Lose only 10% to 16% of successful conceptions as a result of embryonic loss or spontaneous abortions, compared to 27%, and
- Require just 1.8 to 2.3 breeding attempts per calf carried to term, compared to 3.5 attempts.

These major differences between high-production conventional dairy farms and organic farms are brought about by declining animal health and incrementally more serious reproductive problems on farms that strive to maximize production via a regime of hormone and other drug use, coupled with high-energy, grain-based diets (Lucy, 2001; Smith et al., 2000).

Avoiding Bias in the Choice of Measurements

In comparing dairy farm performance, the volume of feed intake and wastes generated by dairy farms are typically expressed relative to some measure of milk output from dairy farm operations (e.g., milk per day, per lactation, or per year). How this basic metric of performance is defined and then quantified has an enormous impact on results.

Studies that compare feed intake or wastes generated per unit of milk produced in a given year or over a single lactation ignore the impact of dairy management systems on cow health and longevity. This oversight is often inadvertent, but skews results against systems that strive to promote cow health and maximize milk and meat production over an animal's life.

This source of bias is rooted in animal physiology. It arises from the significant volumes of animal feed and wastes generated in the two years prior to the birth of a milk cow's first calf. On dairy farms with relatively high replacement rates such as those in Scenario 1, the two years of feed and other inputs required to get a cow into production, and the wastes generated, are amortized over just 1.8 lactations, while on a grass-based farm like those modeled in Scenario 4, the average cow milks through an estimated 4.5 lactations, markedly changing longer-term measures of performance.

Organic dairy farms raising Holsteins require about the same amount of land to sustain a milk cow and the animals needed to keep her in production, but significantly less prime cropland compared to high-production farms feeding large quantities of corn and soybeans. Organic dairy farms milking Jersey cows require an annual average 3.8 acres of land compared to 4.9 acres on high-production conventional farms.

Because certified organic farmers cannot use the synthetic nitrogen fertilizers and pesticides routinely used in growing feed for conventional dairy animals, the environment and public health are spared any adverse impact from these production inputs.

In terms of the wastes generated by dairy farming, most footprint studies focus on the amount of manure, nutrient excretions, and methane emitted per pound or kilogram of milk. Again, virtually all past studies build bias into their results by focusing only on the volume of wastes or methane emitted per pound of milk over a lactation or in a year, rather than per pound of Energy Corrected Milk over a cow's lifetime.

In comparing the wastes generated by the Jersey cows in Scenario 4 to the high-production Holsteins in Scenario 1, it is important to note that the Holstein cows are about 40% heavier and require more feed to support metabolic functions. The Jerseys, on the other hand, require additional feed energy to cover the metabolic expense of walking to, from and over pastures in the course of grazing, and the Jerseys are producing substantially less milk per day, and hence require less feed per day. The SOG calculator takes all these factors into account in projecting feed needs and the wastes generated across the four scenarios.

The Jersey cows in Scenario 4 produce 2.5 kilograms (kg) of manure per kg of unadjusted milk, compared to 2.04, 2.28, and 2.42 kgs by the Holsteins in Scenarios 1, 2, and 3. But in terms of Energy Corrected Milk, the Jersey cows produce the least manure per kg of milk – 2.04 kgs compared to 2.07 kgs in Scenario 1.

Methane is a potent greenhouse gas (GHG) associated with dairy farm operations. It comes from two primary sources – enteric methane from cow belching and flatulence (passing gas), and from manure. Because most high-production conventional farms use freestall barns to house animals, they depend on liquid-based systems to flush manure from alleyways and holding pens. This sort of system typically relies on some sort of liquid/slurry storage system to hold flush water. Lagoon-based systems, a common liquid/slurry storage option, lose 40-times or more methane than the systems used on most organic farms. For this reason, manure-based methane losses are far greater in Scenarios 1 and 2 than 3 and 4.

Per kilogram of unadjusted milk, enteric methane losses in Scenarios 3 and 4 exceed those in Scenarios 1 and 2 by about 10%, but the cows in Scenario 4 emit the least enteric methane per kg of Energy Corrected Milk.

Manure methane losses are five to six-fold higher in Scenarios 1 and 2 because of greater reliance on anaerobic lagoon-based liquid/slurry storage systems. In terms of total methane emissions, Scenario 3 organic farms raising Holsteins produce about one-third less total methane per kg of Energy Corrected Milk, compared to Scenarios 1 and 2, and the Jersey cow and pasture-based organic farms in Scenario 4 produce about one-half the total methane per kg of ECM.

B. Drivers of Performance

This analysis identifies several dairy farm management system features or components that drive overall system performance. Each must be taken into account in comparative studies to avoid systemic bias. In rough order of importance, these factors are:

- Daily milk production levels;
- Cow stress levels and body condition, and resulting impacts on reproduction;
- Milk nutritional quality;
- Degree of reliance and quality of pasture and forage-based feeds;
- Manure management systems; and
- Animal breed.

Enteric methane emissions are an unavoidable outcome of dairy farming.

In terms of cow health and longevity, today's organic farms have preserved through management and animal husbandry levels of cow health and well-being that were common on conventional farms 30 years ago. This achievement is rooted in the core principles and practices incorporated in organic certification rules, including those in the National Organic Program (NOP) rule.

The animal health, milk quality, and environmental benefits of organic dairy farm management systems are likely to increase in the years ahead as the newly promulgated NOP access-to-pasture rule comes into full effect. This rule requires organic dairy cows to obtain a minimum average of 30% of daily dry matter intake from pasture over the grazing season, which must last at least 120 days each year and can be as long as 365 days in some regions. This new rule will increase reliance on pasture on many organic farms and will, as a result, promote average cow health and enhance organic milk quality, while lightening dairy farming's environmental footprint.

The dominant trends in the conventional dairy sector are toward larger farms, higher production, virtually no access to pasture, heavier reliance on performance-enhancing drugs and antibiotics, and substantially greater and more concentrated environmental impacts, especially methane emissions and nitrogen losses from anaerobic lagoon-based manure management systems.

An encouraging series of insights emerged over the course of this study. Milk nutritional quality can be improved through management. Steps taken to improve milk quality tend to enhance animal health and longevity and lighten the environmental footprint of dairy farming. System changes that are good for cows are also beneficial to people drinking their milk, and good for the land and the atmosphere. Such innovation can also improve the farmer's bottom line, especially if the availability of high-quality organic dairy feed and other production inputs increases, a likely outcome as the industry grows in scale and sophistication.

New tools and deeper insights are needed to support efforts by conventional and organic dairy farmers working to improve the safety and quality of milk, enhance animal health, and lighten the environmental footprint of dairy farming. The SOG calculator is one such a new tool that is fully documented, easy to use, flexible, and offered free to anyone hoping to identify the most cost-effective ways to improve the performance of dairy farm operations, for the benefit of the animals and the land, and people and the planet.