Production, Management and the Environment & Forages and Pastures Joint Symposium: Environmental Impact of Beef and Dairy Systems

405 An overview of the environmental impact of beef and dairy systems. J. L. Capper*, *Washington State University, Pullman.*

The livestock industry faces the challenge of providing sufficient safe, affordable, nutritious animal protein to feed the population while maintaining environmental stewardship. Ruminant production systems have been criticized for their contribution to global greenhouse gases, yet US beef and dairy systems have considerably reduced resource use and carbon emissions over time. Advances in nutrition, genetics and management allowed dairy cow productivity to increase 4-fold between 1944 and 2007, with 21% of the animals, 23% of the feed, 35% of the water and 10% of the land required to produce one kg of milk in 2007 compared with 1944. Similar advances in the US beef industry facilitated a 31% increase in beef yield per animal and 124-d reduction in the time period from birth to slaughter between 1977 and 2007. Feedstuff use was thus reduced by 19%, water use by 14%, land use by 34% and the carbon footprint was 18% lower per kg of beef in 2007. Environmental gains result from a combination of improved productivity and reduced resource requirements within the non-productive sector of the supporting population. Individual cow and herd data records suggest that the dairy industry may continue to considerably improve milk yield before a plateau is reached. Further gains may be made by reducing population body mass – producing cheddar cheese from Jersey cows (454 kg mature weight) with increased milk component concentrations (4.8% fat and 3.7% protein) compared with their Holstein cohorts (680 kg mature weight; 3.8% fat and 3.1% protein) reduced the carbon footprint per kg of cheese by 20% despite the greater Holstein milk yield (29.1 kg/d vs. 20.9 kg/d). Within the beef industry, desirable slaughter weight appears to have plateaued at an average of 590 kg, yet resource use and waste output may be mitigated by improving growth rate. Indeed, growth-enhancing technology use within conventional beef production reduced land use by 45% and carbon emissions by 42% per kg of beef compared with grass-finished systems. To improve future environmental sustainability it is crucial to maintain access to management practices and technologies that improve productivity.

Key words: greenhouse gases, environmental impact, productivity

406 Whole farm assessment—Using precision agriculture to assess, measure, and mitigate environmental impacts of on-farm practices. Y. Wang*, *Dairy Research Institute, Rosemont, IL.*

The objective of this presentation is provide an example of a modeling tool that helps individual dairy producers assess and mitigate on-farm GHG emissions. The greenhouse gas (GHG) life cycle assessment (LCA) for fluid milk, commissioned by the Innovation Center for US Dairy and conducted by the Applied Sustainability Center at the University of Arkansas, evaluated GHG emissions for milk production in the United States. On-farm activities accounted for more than 70% of emissions. A compendium study is also underway to assess other impacts such as eutrophication, land use, biodiversity, and toxicity. Together, these LCAs will provide the basis for the development of easy-to-use measurement tools for producers. One such tool is Dairy FarmSmart, a modeling tool that allows farmers to assess, measure, and mitigate on-farm environmental impacts based upon farm-specific climate, air quality, soil, land, and watershed information. Two existing modeling tools, DeNitrification-DeComposition (DNDC) and Water Use and Quality Assessment, are integrated and enhanced. DNDC is used for predicting crop growth, soil temperature and moisture regimens, soil carbon dynamics, nitrogen leaching, and emissions of trace gases. The Water Use and Quality Assessment is based on the fluid milk LCA. It includes implementation of the P-eutrophication model at a local scale and a multi-scale link to the larger scale with the 0.5 by 0.5 degree watershed (approximately 50 km by 50 km.); hydrological balance of the local streams and river from plot scale up to the 0.5 degree regional scale; evaluation of local impacts of water use at farm level; and integration of the farm's direct local impact within the overall life cycle impact assessment. The desired outcome is to give producers the ability to identify on-farm management practices that will minimize GHG emissions and maximize conservation efforts.

Key words: greenhouse gas emissions (GHG), life cycle assessment (LCA), environmental impact

407 Measurement strategies for reducing enteric methane from beef and dairy production. K. A. Beauchemin* and S. M. McGinn, *Agriculture and Agri-Food Canada, Lethbridge, AB, Canada.*

There is considerable uncertainty in the estimates of enteric methane (CH_4) production from ruminants attributed to variability at the farm level due to diet and management. Quantification of enteric CH_4 emissions is essential for understanding underlying processes controlling methanogenesis, assessing mitigation practices and producing national greenhouse gas inventories. Various techniques are available for measuring enteric CH_4 production, and several factors need to be considered when selecting the most appropriate technique. Most important is an understanding of the required level of accuracy and precision. When evaluating mitigation strategies, it is essential to use a measurement technique and experimental design that will enable detection of differences between treatments, which are often small (<15%). Whole animal chambers have a high degree of accuracy and precision, and are therefore ideal for treatment comparisons. However, dry matter intake and diet composition of animals in chambers can differ from their herd mates. The sulfur hexafluoride (SF_6) tracer technique allows measurement of enteric CH_4 emissions of ruminants in their natural environment. A permeation tube filled with SF_6 is inserted into the rumen of the animal and a collection apparatus is mounted on or near the animal. The tracer technique has greater between-animal and within-animal variability than chambers, and consequently a large number of animals (~4-times more than chambers) and multiple measurement days are needed. Micro-meteorological techniques are useful for measuring emissions from groups of animals (pens, small paddocks, entire feedlots, barns) and are ideal for inventory purposes. Recent advances have shown that they can also be used to evaluate treatment differences, although replication of groups can be difficult. Several newer methods such as laser guns, feeders equipped with sensors, and assessment of milk fatty acid profiles may offer potential for monitoring emissions on commercial farms. Each technique for measuring enteric CH_4 has its advantages and limitations, and the ideal method of choice depends on the objective of the study.

Key words: methane, greenhouse gases, measurement

408 Dairy cropping systems and air quality. F. M. Mitloehner*, *University of California, Davis.*

Recent studies have identified animal feeds as a significant volatile organic compound (VOC) source contributing to regional ozone challenges. Specifically, the ozone formation potentials of livestock feed emissions were measured on representative field samples using a transportable smog chamber. Seven feeds were considered: cereal silage (wheat grain and oat grain), alfalfa silage, corn silage, high moisture ground corn (HMGC), almond shells, almond hulls, and total mixed ration. The VOC flux measured from silage and total mixed ration was two orders of magnitude higher than comparable fluxes from animal waste. Chamber measurements confirm that animal feed VOC emissions are significantly higher than animal waste emissions and several of the animal feed derived VOCs have potentially high ozone formation potentials. While recognizing the importance of this environmental challenge, it is important to note that loss of these volatile gases has also financial implications to the dairy producer. Dry matter losses can range from 10 to 25% and while the majority of gas losses is CO_2, VOC constitute a significant portion of overall feed losses that might be preventable though optimized silage management.

Key words: silage, ozone, volatile organic compounds

409 Cow of the future—A research roadmap for mitigating enteric methane emissions from dairy cattle. W. R. Wailes*[1], J. R. Knapp[2], and M. D. Welch[3], [1]*Colorado State University, Fort Collins,* [2]*Fox Hollow Consulting LLC, Columbus, OH,* [3]*Dairy Research Institute, Rosemont, IL.*

The Innovation Center for US Dairy has committed to reducing greenhouse gas emissions from dairy production by 25% (from 2008 levels) by 2020. Enteric methane emissions are the largest contributor to greenhouse gas emissions in the dairy chain, comprising approximately 35% of the total greenhouse gas emissions associated with US dairy production. The objective of this presentation is to present a roadmap for future research that reduces enteric methane per unit of milk produced by cows during the process of feed digestion. This roadmap, called the Cow of the Future Research Agenda, identifies and evaluates research opportunities that will lead to future mitigation technologies and applications. An expert panel of university and industry-based scientists identified 8 categories of future research needs: rumen microbial genomics and ecology; rumen function and modifiers; enhancing feed quality and feed ingredient usage to improve digestibility and feed efficiency; genetic approaches to increase individual cow productivity; management approaches to increase individual cow productivity; management of herd structure to reduce number of cow-days of non-productive animals (replacement heifers and dry cows); development and refinement of methane measurement techniques; and modeling efforts to quantitatively integrate the knowledge gained in the above areas. Implementation of existing technologies and management practices in the dairy industry along with continued genetic progress in milk yields is expected to result in 10 to 12% reductions of methane emissions per unit of milk over the next decade. To achieve the additional 13 to 15% reduction to reach the overall goal of a 25% reduction requires investment in research to identify and develop new strategies. The desired outcome of the Cow of the Future Research Agenda is to encourage research and development in the designated categories by fostering collaborative grant submissions and providing opportunities for collegial interaction by hosting symposia such as Production, Management and the Environment & Forages and Pastures Joint Symposium and other conferences.

Key words: dairy, enteric methane, greenhouse gas emissions (GHG)

410 Diet formulation as an effective tool for mitigating the environmental impact of dairy and beef cattle operations. A. N. Hristov*, *Pennsylvania State University, University Park.*

Dairy and beef cattle operations are responsible for a significant portion of the N, P, ammonia, and green-house gas (GHG) agricultural emissions in the US In watersheds with intensive animal production (the Chesapeake Bay, for example), agriculture can account for as much as 30 to 50% of the total N and P loads. Gaseous emissions from animal facilities or field application of manure can also be a significant contributor to the environmental footprint of the livestock industries. It has been repeatedly demonstrated that nutrient emissions from animal operations are directly related to composition of the diet fed and whole-farm nutrient inputs. In all cases, the possibility of reducing the environmental impact of dairy and beef cattle operations through nutrition is intrinsically related to improving feed efficiency. For example, an average dairy cow will utilize approximately 25 to 28% (SD = 41 and 36, respectively) of the feed N for milk protein secretion. Beef cattle typically retain 10 to 20% of the intake N as weight gain. Highly efficient dairy systems, however, may capture up to 38 or even 40% of the feed N into milk protein. To a large part, this increased efficiency is a result of diet formulation and reduced feed N input. More efficient utilization of feed N for production purposes corresponds to lower manure N losses and gaseous emissions. Feeding to or below NRC requirements (both dairy and beef) has been shown to have a marked impact on P losses with no measurable effect on animal productivity, reproduction, or health. Reducing inputs of some nutrients (particularly N), however, can negatively impact animal productivity (or milk composition in dairy cows). Formulating for metabolizable protein and perhaps supplementation with synthetic amino acids, for example, may be a feasible approach for maintaining production with low-N input rations. In some cases, targeting efficiency, not necessarily maximum production, may be a viable nutrient management strategy.

Key words: environmental impact, diet formulation, livestock

411 Managing the environmental impact of pasture production systems. K. A. Johnson* and C. D. Gambino, *Washington State University, Pullman.*

All animals impact their environment. The form and magnitude of that impact depends on the animal system. There is increasing interest in producing animal products using pasture systems and these systems must be designed and managed to be productive and minimize environmental impact. Grazing cattle affect the environment through plant selection, trampling of plants, deposition of fecal and urinary nutrients, leaching of nitrogen (N), and emission of greenhouse gases (GHG) from enteric fermentation or soil biogeochemical processes. Grazing cattle spatially redistribute plant-N which causes N-cycling changes in plants and soil which alters the carbon:N ratio of plants. Trampling can increase litter turnover, and nutrient cycling can accelerate in patches where manure and urine are deposited. The primary GHG associated with pasture systems are methane (CH_4) and nitrous oxide (N_2O) although some ammonia (NH_3) losses do also occur. Manipulation of pasture composition through fertilization, management-intensive grazing systems, and strategic supplementation can affect the GHGs emitted by livestock and soils. Factors affecting N_2O emissions from grazing lands include the ecosystem (pasture or rangeland), animal management (timing and duration of grazing and stocking rate),

riparian area management, and fertilization (timing and application method). Grazing animals affect soils in both direct and indirect ways. Manure deposition on the soil directly affects soil microbial activity, N mineralization rate, and ultimately plant productivity. Indirectly, grazing can lead to death of leaves, decomposition of litter, enhanced soil microbial activity, N mineralization and altered plant productivity. Management intensive grazing strategies that maintain plants in the vegetative stage (reduced fiber) can alter ruminal fermentation to decrease CH_4 emissions. Fertilization strategies that provide plants with N when they are actively growing reduce leaching of NO_3-, NH_3 volatilization and N_2O emissions. Prior to implementation, pasture production systems should be designed, assessed and managed as a dynamic system to minimize environmental impact.

Key words: pasture, greenhouse gases, management