# Production, Management and the Environment: Surveys and Models I

**702 Expected value of beef cattle breeding strategies: Sexed versus non-sexed semen.** E. D. Lord*[1], N. J. Olynk Widmar[1], B. Gloy[1], W. M. Hilton[2], and C. A. Wolf[3], [1]*Purdue University, Department of Agricultural Economics, West Lafayette, IN,* [2]*Purdue University, College of Veterinary Medicine, West Lafayette, IN,* [3]*Michigan State University, Department of Agricultural, Food, and Resource Economics, East Lansing.*

The US beef cattle herd is currently the smallest since 1952. Given current market conditions, what strategies should producers pursue to breed beef cattle and grow their herds? The objective of this research is to evaluate the expected value (EV) of artificial insemination (AI) beef breeding strategies. Sexed semen has only recently become a topic of interest for beef cattle. Producers may consider AI using non-sexed semen or sexed semen; a spreadsheet-based model was developed to calculate the EV of breeding a heifer and/or cow with non-sexed semen AI and sexed semen AI. Multiple scenarios were investigated to assess the differences in EV among breeding strategies. Sex ratios were assumed at 49.2% female for non-sexed AI and were investigated at assumptions of 75% and 90% of the desired sex for sexed AI. Both male and female sorted semen were analyzed as potential strategies. Sexed semen was assumed to yield a conception rate (CR) 75% to 85% of that of non-sexed semen. Costs per AI were held constant at $20.00/non-sexed AI and $30.00/AI for 90% bull-sorted sexed AI of approximately the same genetic value. A sample scenario was created in which bull and heifer calves were valued at $450 and $300, respectively. The value of the average calf increased by approximately $60 with 90% bull-sorted sexed semen. Assuming 90% bull-sorted sexed semen yielded 85% of non-sexed AI conception rate (61%) and simplifying with a 100% AI submission rate, 2 AI with sexed semen yielded an EV of approximately $20 higher than that of 2 AI with non-sexed semen. All else equal, in this scenario, to achieve an EV with 2 sexed semen AI equal to that with 2 non-sexed semen AI, the sexed semen must yield at least 78% of the conception rate of non-sexed semen. Ceteris paribus, 2 sexed semen AI yielded an equal EV to 2 non-sexed AI, as long as the bull calf value was at least $426. This model provides insight into key tradeoffs between beef breeding strategies. Other considerations in the model include the effects of carrying costs for open animals, changing AI costs, and varying reproductive performance to various breeding methods.

**Key Words:** sexed semen, beef reproduction, beef breeding

**703 Meta-analysis of consumer willingness to pay for specialty attributes of beef.** R. White*[1] and M. Brady[2], [1]*Department of Animal Sciences, Washington State University, Pullman,* [2]*School of Economic Sciences, Washington State University, Pullman.*

Improving sustainability of beef production systems will help ensure a long-term food supply. Sustainability of a system can be quantified via measures such as environmental impact (EI), economic viability and social acceptability. An accepted metric for social acceptability is consumer willingness to pay (WTP). The objective of this study was to perform a quantitative survey of consumer WTP for various attributes of beef to identify the consumer WTP for lowered EI. An Agricola database search for consumer WTP for beef from 2003 to 2012 returned 16 usable studies representing 44 treatments applied to over 11,000 consumers in 6 countries. Following a Hedonic approach, breaking goods into constituent parts, studies were categorized using 21 binary dummy variables to describe study location, methodology and beef attribute. For each variable, 95% confidence intervals were calculated to determine the expected mean and range of consumer WTP. A multi-variate regression was used to relate consumer WTP to location and methodological variables, 4 single-attribute variables (health, local, EI or quality) and 3 dual-attribute variables (health+local, health+EI, local+EI). Confidence intervals indicated consumer WTP for beef attributes related to quality (tenderness, yield) or personal health (safety, traceability, no GMO, no antibiotics/hormones, vegetarian diet, organic) was between a 35% and 104% premium (mean = 51%). The WTP for EI or local economic impact was a premium of 6% to 33% (mean = 20%). Results agree with existing literature that consumers are WTP more for private goods than public goods. The regression model was significant ($P = 0.0003$) and explained 67% of the variability in WTP. When location variables were used to predict WTP for US consumers, the model indicated WTP a 4% premium for environmental attributes. When products with environmental attributes also had local or health benefits, WTP increased to a 23% or 82% premium, respectively. Consumers show measurable WTP for non-quality attributes of beef including reduced EI; thus, WTP should be included in assessments of methods to improve sustainability of beef production.

**Key Words:** meta-analysis, environmental impact, willingness to pay

**704 Environmental footprints of beef production at the U.S. Meat Animal Research Center.** C. A. Rotz*[1], B. J. Isenberg[1], K. R. Stackhouse-Lawson[2], and E. J. Pollak[3], [1]*USDA/ARS, University Park, PA* [2]*National Cattlemen's Beef Association, Centennial, CO,* [3]*USDA/ARS, Clay Center, NE.*

Environmental footprints of beef produced at the US Meat Animal Research Center (MARC) in Clay Center, Nebraska were determined to quantify improvements achieved over the past 40 years. Relevant information for MARC operations was gathered and used to represent their production system with the Integrated Farm System Model. The MARC farm, cow calf and feedlot operations were each simulated over recent historical weather to evaluate performance, environmental impact and economics. The current farm operation included 840 ha of alfalfa and 1,160 ha of corn to produce feed predominately for the beef herd of 5,500 cows, 1,200 replacement heifers and the 3,724 cattle finished each year. Spring and fall cow calf herds were fed on 9,710 ha of pastureland supplemented with hay and silage produced by the farm operation. Feedlot cattle were backgrounded 3 mo on hay and silage and finished over 7 mo on a diet high in corn grain and purchased wet distiller's grain. Model simulated predictions for 2011 were within 1% of actual records for feed production and use, energy use, and production costs. A 25-year simulation of their current production system gave a carbon footprint of 10.9 kg of $CO_2$e/kg BW sold, and the energy required to produce that beef (energy footprint) was 26.5 MJ/kg BW. Total water use (water footprint) was 21,300 l/kg BW sold, and the water footprint excluding that obtained through precipitation was 2,800 l/kg BW. Simulation of the production practices of 2005 indicate that the use of distiller's grain in animal diets has had a relatively small impact on environmental footprints except that reactive nitrogen loss has increased 10%. Compared with 1970, the carbon footprint of the beef produced has decreased 6% with no change in the energy footprint and a 3% reduction in the reactive nitrogen footprint. The water footprint, excluding precipitation, has increased 42% due to greater use of irrigated corn production. These results support that progress has been made in reducing some environmental impacts of beef produced at MARC.

**Key Words:** beef, environment, carbon footprint

**705 Environmental, social, and economic footprints of current and past beef production systems.** K. R. Stackhouse-Lawson*[1], C. A. Rotz[2], B. J. Isenberg[2], E. J. Pollak[3], T. Battagliese[4], B. Ulhman[4], C. Barcan[4], I. Schulze[5], J. Silva[5], and J. O. Reagan[1], [1]*National Cattlemen's Beef Association, Centennial, CO,* [2]*USDA-ARS, Pasture Systems and Watershed Management Research Unit, University Park, PA,* [3]*USDA-ARS-NPA, Roman L. Hruska U.S. Meat Animal Research Center, Clay Center, NE,* [4]*BASF Corporation, Nutrition and Health, Florham Park, NJ,* [5]*BASF Corporation, Fundação Espaço ECO, Sao Bernardo do Campo, Brazil.*

The beef industry has defined sustainability as meeting the growing demand for beef by balancing environmental responsibility, economic opportunity and social diligence. Accurately measuring sustainability is challenging, as the beef supply chain is one of the most complex food systems in the world. As the first and largest research project of this kind, this study represents an innovative approach toward creating a more sustainable beef product. Our objective is to establish a sustainability baseline (including environmental, economic, and social footprints) for the US beef industry by quantifying life cycle inputs and outputs for beef production over time. Our approach is to use a combination of models. The USDA-ARS Integrated Farm System Model (IFSM) is used to simulate the environmental and economic footprints from cradle to farm-gate. The socio-eco-efficiency tool (SEEBALANCE) extends this analysis by determining the environmental, economic, and social impacts of beef from cradle to grave providing a comprehensive assessment of sustainability. As an initial step, the environmental impacts and economics of beef production at the US Meat Animal Research Center were determined through simulation with the IFSM. These results were combined with primary data from the packer, case ready, retail, and consumer segments of the beef value chain for 2005 and 2011 using SEEBALANCE. This approach quantified sustainability considering economic, social and ecological impacts along all segments of the beef value chain expressed in 0.45 kg of minimally processed boneless edible consumed beef. Environmental impacts included solid waste contributions, greenhouse gas emissions, ozone depleting potential, photochemical ozone creation potential, acidification potential, emissions to water, resource consumption, land use and energy consumption. Social impacts were measured using toxicity potential, occupation illnesses and accidents, and risk. Economics for the full chain were expressed in consumer price. Overall, the sustainability of the US beef industry, given the present assumptions, has improved by 9% in 6 yr.

**Key Words:** beef, sustainability, life cycle assessment

**706 Life cycle assessment of the production of one kilogram of milk in six buffalo farms.** G. Pirlo*[1], S. Carè[1], V. Fantin[2], F. Falconi[3], P. Buttol[2], C. Pacelli[4], G. Terzano[1], and P. Masoni[2], [1]*Consiglio per la ricerca e sperimentazione in agricoltura (CRA), Cremona, Italy,* [2]*ENEA, Italian National Agency for New Technologies, Energy and Sustainable Economic Development, Bologna, Italy,* [3]*LCA-lab SRL, Bologna, Italy,* [4]*Dipartimento di Scienze delle Produzioni Animali, Università della Basilicata, Potenz, Italy.*

The purpose of this study was to quantify the environmental impacts of the production of milk of Italian Mediterranean buffaloes. For this purpose, life cycle assessment (LCA) was used in a sample of 6 farms. The functional unit was 1 kg of normalized buffalo milk (LBN), with a reference milk fat and protein contents of 8.3 and 4.73% respectively. The system boundaries included the agricultural phase of buffalo milk chain from cradle to farm gate. Impact categories were: global warming (GW), abiotic depletion (AD), photochemical oxidation (PO), acidification (AC), and eutrophication (EU). Refernce units were kg of $CO_2$eq for GW, kg of Sbeq for AD, kg of $C_2H_4$eq for PO, kg of $SO_2$eq for AC, and kg of $PO_4^{3-}$eq for EU. Farm activities were (1) on-farm energy consumption (EC); (2) manure management (MM); (3) manure application (MA); (4) on-farm feed production (ONFP, comprising production and application of chemical fertilizers and pesticides); (5) off-farm feed production (OFFP); (6) enteric fermentation (EF); (7) transports of off-farm feeds, chemical fertilizers and pesticides from suppliers to farms (TR). Farms were characterized by a herd size of 361 ± 40.6 buffaloes and a production of 2,069 kg/head/year of LBN. LCA was performed with the support of SimaPro 7.3.3. software. The average environmental impacts associated with 1 kg of LBN were: GW 5.02 (±1.14) kg of $CO_2$eq; AD 5.08 E-1 (±2.04 E-1) kg of Sbeq; PO 6.72 E-4 (±2.00 E-4) kg of $C_2H_4$eq; AC 6.52 E-2 (±1.98 E-2) kg of $SO_2$eq; EU 3.28 E-2 (±1.21 E-2). kg of $PO_4^{3-}$eq. Activities with major effects on GW were EF (37% ± 7.78) and MA (19.3% ± 3.0); on AD were EC (31.4% ± 12.6) and ONFP (32.6 ± 9.7); on PO was EF (37% ± 7.8); on AC were MM (53.6% ± 7.9) and MA (26.3% ± 4..5); on EU were MM (23.7% ± 5.9), MA (36.8% ± 12.1) and OFFP (26.6% ± 13.9). Normalization analysis showed that the major contributions to the environmental impact of LBN production come from GW, AC and EU; whereas those of AD and PO are negligible.

**Key Words:** life cycle assessment, buffalo milk

**707 Assessment of culling risk and economic outcomes in dairy herds.** G. M. Schuenemann*[1] and K. N. Galvão[2], [1]*Department of Veterinary Preventive Medicine, The Ohio State University, Columbus,* [2]*Large Animal Clinical Sciences, University of Florida, Gainesville.*

It is common to observe large among-herd variation in culling risk while having similar reproductive performance. The objective was to assess the effect of 2 culling risks (28% vs 38%) on the economic outcomes of dairy herds with the same reproductive performance using an individual cow-based stochastic model. For the simulation, 2 culling risks (28% vs 38%) were compared using the same reproductive program and performance. Cows were enrolled in an Ovsynch (OV) preceded by Presynch with 2 injections of PGF 14 d apart, and OV for resynchronization of open cows at 32 d after AI. Also, cows undergo estrous detection (ED) and AI after first AI, and cows diagnosed open 32 d after AI are resynchronized using OV. Cows were not inseminated after 365 DIM and open cows were culled after 450 DIM. Culled cows were immediately replaced with a primiparous cow. Herd was maintained at 1,000 cows. Mortality was set at 6% and abortion at 11.3%. The dry period and VWP was 60 d. Conception rate to first service was set to 32% (decreased by 2.5% for every subsequent service), and ED was set to 60%. Accuracy of ED and COM with each injection were set at 95%. Net daily value was calculated by subtracting the costs with replacement heifers ($1,600/heifer), feeding costs ($0.25/kg of lactating cow diet; $0.15/kg of dry cow diet), breeding costs ($0.15/cow/d for ED; $2.65/dose PGF; $2.4/dose GnRH; $0.25/injection administration), and other costs ($2.5/d) from the daily income with milk sales ($0.44/kg milk), cow sales ($2/kg live weight), and calf sales ($200/calf). Simulation was performed until steady-state was reached (4000 d), then average daily values for the subsequent 1000 d was used to calculate profit ($/yr). According to the model (same herd size, synchronization program and reproductive performance), the annual profit was $23687 higher for 28% compared with 38% culling risk. Culling affects the bottom line of dairy operations and the underlying causes should be investigated to develop preventive procedures to ensure optimum level of culling risk by considering both welfare and profitability.

**Key Words:** culling risk, economics, dairy herd

**708 Effect of milking personnel performance and turnover on milk losses in dairy herds.** G. M. Schuenemann*, M. G. Maquivar, S. Bas, and J. D. Workman, *Department of Veterinary Preventive Medicine, The Ohio State University, Columbus.*

It is common to observe large within-herd variation in milking personnel performance (MPP) and turnover (TO) over time. Assessing team performance, resolution of conflicts, and comprehensive training of dairy personnel are critical tasks to achieve consistent performance of dairy herds. The objective was to assess the effect of MPP (95% vs 85%) and TO of personnel (5% vs 30%) on milk losses of dairy herds. For the simulation, the performance of each milker (compliance with milking routine protocol) was set to 85% or 95%. Milk losses were set at 1 kg/cow/d due to lack of udder stimulation. An adjustment period of 14 d with a 66.5% performance was estimated for each new personnel. The overall risk performance (%; RP) was estimated taking into account the team milking performance and TO. The number of cows at risk (n/d) was estimated based on the RP (10 milkers) and herd size (2000 cows). Milk price was set at $0.41/kg. Costs for herd audit were set at $1000 and training program at $1000 (for 4 sessions per yr). Milk losses ($/yr/herd) and return on investment (ROI) were estimated. For a 2000-cow herd, the overall effect of TO (5% vs 30%) on milk losses was $6744 while the overall effect of RP (85% vs 95%) on milk losses was $27920. Cows at risk and milk losses were higher ($14 per cow/yr) for RP 85% with 30% TO (342 cows/d) compared with RP 95% with 5% TO (110 cows/d). The ROI for high performance teams (RP 95% and 5% TO) was $18 for every $1 invested (herd audit and training). The estimated ROI assumes that facilities are adequate, participants are willing to learn and apply the newly learned concepts, and the herd audit correctly identifies the needs and the training program correctly addresses them. Both TO and RP affect the bottom line of dairy herds. Frequent assessment of performance, educational needs, and training of dairy personnel should be top priorities for dairy operations to achieve a consistent and efficient herd performance over time.

**Key Words:** human resources, milk loss, dairy herd

**709 Retention pay-off prediction using machine learning algorithms.** S. Shahinfar*, A. S. Kalantari, V. Cabrera, and K. Weigel, *Department of Dairy Science, University of Wisconsin-Madison, Madison.*

Culling decisions have a major effect on dairy farm profitability. Dynamic programming (DP) has been widely used for finding the optimal replacement policies in dairy cattle. However, DP models are computationally intensive and might not be practical for daily decision making. Hence, the ability of machine learning to provide fast and accurate predictions of non-linear and inter-correlated variables makes it an ideal methodology. Milk class (1–5), lactation number (1–9), month in milk (1–20), and pregnancy status (0–9) were used to describe a cow in the DP model. Twenty-seven scenarios based on all combinations of 3 levels of milk production, milk price, and replacement cost were solved with the DP model, resulting in a data set of 122,716 records, each with a calculated retention pay-off. Then, a machine learning model tree algorithm was used to mimic the evaluated RPO in DP. The correlation coefficient factor was used to observe the concordance of RPO evaluated by DP and RPO predicted by the model tree. The obtained correlation coefficient was 0.991 with corresponding value of 0.11 relative absolute error. At least 100 instances were required per model constraint, and resulting in 204 total models. When these model s were used for binary classifications of positive and negative RPOs, error rate were %1 false negatives and %9 false positives. Applying this trained model from simulated data for prediction of retention pay-off for 102 actual culling records from UW-Madison dairy herd resulted in a 0.994 correlation with 0.10 relative absolute error rate.

**Key Words:** machine learning, retention pay-off, prediction

**710 Model selection, estimation and cross validation of methane emissions prediction equations.** L. E. Moraes*[1], E. Kebreab[1], A. B. Strathe[2], J. G. Fadel[1], and D. P. Casper[3], [1]*University of California, Davis,* [2]*University of Copenhagen, Copenhagen, Denmark,* [3]*South Dakota State University, Brookings.*

The quantification of methane emissions from livestock is essential in the development of national greenhouse gas inventories and in the assessment of mitigation strategies. Various prediction models have been developed over the past decade but predictive ability remains poor. The objective of this study was to develop methane prediction equations, using 1,111 methane emission records from 298 lactating cows, through the use of robust statistical techniques. Measurements were conducted through indirect calorimetry at the former USDA Energy Metabolism Unit at Beltsville, Maryland. Three model complexity levels (i.e., GE, Dietary and Animal levels) were specified for which the dimension of parameter space increased sequentially. A Bayesian approach was adopted in which statistical inference was based on Markov chain Monte Carlo methods. Key covariates to predict methane emissions at each model complexity level were identified through a Reversible Jump Markov Chain Monte Carlo sampler. The most probable model, conditional on the observed data, at each complexity level was estimated with a Bayesian hierarchical model. Residuals were modeled with a student-t distribution providing robust inference. Equations were evaluated through a K-fold cross validation procedure. Model selection was based on achieving high posterior probabilities ($P > 0.74$) across all complexity levels. Models fitted at GE (1), dietary (2) and animal (3) levels were: (1) $CH_4$ (MJ/d) = 3.25 (0.42) + 0.043 (0.001) × GEI (MJ/d); (2) $CH_4$ (MJ/d) = 0.2242 (0.71) + 0.042 (0.001) × GEI (MJ/d) + 0.124 (0.01) × NDF (% DM) − 0.329 (0.09) × EE (% DM); (3) $CH_4$ (MJ/d) = −9.317 (1.06) + 0.042 (0.001) × GEI (MJ/d) + 0.094 (0.01) × NDF (% DM) - 0.381 (0.09) × EE (% DM) + 0.008 (0.001) × BW (kg) + 1.622 (0.11) × Milk Fat (%). Mean square prediction error for the GE, dietary and animal complexity levels, expressed as a proportion of $CH_4$ emissions means were 18.1, 17.9 and 15.6%. Equations developed here outperformed current models from the literature and will improve the accuracy in the prediction of methane emissions in national greenhouse gas inventories.

**Key Words:** methane emission, prediction, lactating cow