NC 1042: 2011 - 2012 Station Report

A. PROJECT NAME: Management Systems to Improve the Economic and Environmental Sustainability of Dairy Enterprises (Rev. NC-1119)

B. COOPERATING AGENCY and personnel: *UNIVERSITY OF WISCONSIN, Dairy Science,* ***Victor E. Cabrera***

C. WORK PROGRESS AND PRINCIPAL ACCOMPLISHMENTS and

D. USEFULNESS OF FINDINGS:

The effect of reproductive performance on the dairy cattle herd value assessed by integrating a daily dynamic programming with a daily Markov chain model.

Kalantari, A., and V. E. Cabrera. The objective of this study was to determine the effect of reproductive performance on the dairy cattle herd value under optimal replacement policies. The herd value was defined as the herd's average retention payoff (RPO). Individual cow RPO is the expected profit from keeping the cow compared with immediate replacement. First, a daily dynamic programming model was developed to calculate the RPO of all cow states in a herd. Second, a daily Markov chain model was applied to estimate the herd demographics. Then, the herd value was calculated by aggregating the RPO of all cows in the herd. Cow states were described by 5 milk yield classes (76, 88, 100, 112 and 124% with respect to average), 9 lactations, 750 d in milk and 282 d in pregnancy. Five different reproductive programs were studied (RP1 to RP5). The RP1 used 100% timed artificial insemination (TAI; 42% conception rate for 1st TAI and 30% for 2nd and later services) and the other programs combined TAI with estrus detection. The proportion of cows receiving AI after estrus detection ranged from 30 to 80% and conception rate ranged from 25 to 35%. These five reproductive programs were categorized according to their 21 d pregnancy rate (21d PR), which is an indication of the rate the eligible cows become pregnant every 21 d. The 21d PR was 17% for RP1, 14% for RP2, 16% for RP3, 18% for RP4, and 20% for RP5. Results showed a positive relationship between 21d PR and the herd value. The most extreme herd value difference ($/cow per yr) between two reproductive programs was $77 for average milk yield (RP5 – RP2); $13 for lowest milk yield (RP5 – RP1); and $160 for highest milk yield (RP5 – RP2). Reproductive programs were ranked based on their calculated herd value. With exception of the best reproductive program (RP5), all other programs showed some level of ranking change according to milk yield. The most dramatic ranking change was observed in RP1, which moved from being the worst ranked for lowest milk yield to the second best ranked for highest milk yield. Within a reproductive program the RPO changed based on the stage of lactation at pregnancy. Cows getting pregnant in the early stage of the lactation had higher RPO compared to getting pregnant later in the lactation. However, the RPO at calving were similar for early and late lactation pregnancies.

A daily herd Markov-chain model to study the reproductive and economic impact of reproductive programs combining timed artificial insemination and estrous detection.

Giordano J. O., A. S. Kalantari, P. M. Fricke, M. C. Wiltbank, and V. E. Cabrera. The objective was to compare the economic and reproductive performance of programs combining timed artificial insemination (TAI) and different levels of AI after estrus detection (ED) using a daily Markov-chain model. A dairy herd was modeled with every cow following daily probabilistic events of aging, replacement, mortality, pregnancy, pregnancy loss, and calving. The probability of pregnancy

depended on the combination of probability of insemination and conception rate (CR). All non-pregnant cows had a probability of pregnancy between the end of the voluntary waiting period and days in milk cutoff for AI. After the cutoff, cows were labeled as "do-not-breed" and replaced when milk production was below a minimum milk threshold. A similar model was created to represent a replacement heifer herd to simulate and adjust the supply and demand of replacements. The net value (NV) of a program was the sum of: milk income over feed cost (IOFC), replacement and mortality cost, income from newborns, and reproductive costs. The model was used to compare the NV of 19 programs. One program used 100% TAI (42% CR 1st TAI and 30% for 2nd and later services), whereas the other programs combined TAI with ED. The proportion of cows receiving AI after ED for the combined programs ranged from 30 to 80% with levels of CR of 25, 30, and 35%. As the proportion of cows receiving AI after ED increased, the CR of cows receiving TAI decreased. The combined programs with CR of 35% for cows receiving AI after ED had the greatest NV and reproductive performance at all levels of ED. The program using 100% TAI had greater NV and better reproductive performance than all programs with 25% CR after ED inseminations while it had very similar performance than combined programs with up to 60% of cows receiving AI after ED and 30% CR. The factor with the greatest relative contribution to the differences among programs was IOFC followed by replacement and reproductive costs. Adjusting the days in milk cutoff for AI to match the supply and demand of heifer replacements improved the NV of all programs except for those with 25% CR after ED which had either no change or a decrease in NV. In summary, the economic value of reproductive management programs combining TAI and ED depended on the proportion of cows receiving AI after ED and the resulting CR. Adjusting the heifer supply and demand increased the NV of programs with heifer surplus and decreased the NV of programs with heifer deficit.

A simple formulation and solution to the replacement problem: A practical tool to assess the economic cow value, the value of a new pregnancy, and the cost of a pregnancy loss.

*Cabrera, V. E. This study contributes to the research literature by providing a new formulation of the cow replacement problem and it also contributes to the Extension deliverables by providing a user-friendly decision support system tool that would more likely be adopted and applied for practical decision-making. The cow value, its related values of a new pregnancy and a pregnancy loss, as well as their associated replacement policies, determines profitability in dairy farming. One objective of this study was to present a simple, interactive, dynamic, and robust formulation of the cow value and the replacement problem including expectancy of cow's future production and replacement's genetic gain. The proven hypothesis of this study was that all of the above requirements could be achieved by using a Markov chain algorithm. The Markov chain model allowed to: 1) calculate a forward expected value of a studied cow and its replacement; 2) use a single model (the Markov chain) to calculate both the replacement policies and the herd statistics; 3) use a pre-defined, already established, farm reproductive replacement policy; 4) include farmer's assessment of a cow expected future performance; 5) include farmer's assessment of genetic gain with a replacement; and 6) use a simple spreadsheet or an online system to implement the decision support system. Results clearly demonstrated that the decision policies found with the Markov chain model were consistent with more complex dynamic programming models. The final user-friendly decision support tool is available at DairyMGT.info → Tools → The Economic Value of a Dairy Cow. This tool calculates the cow value instantaneously, is highly interactive, dynamic, and robust. Studying a Wisconsin dairy farm with the model, the solution policy called for replacing nonpregnant cows 11 months after calving or months in milk (**MIM**) if first lactation and 9 MIM if later lactations. The cow value for an average second lactation cow*

was: 1) when nonpregnant: a) $897 in MIM = 1 and b) $68 in MIM = 8; 2) when just became pregnant: a) $889 for a pregnancy in MIM = 3 and b) $298 for a pregnancy in MIM = 8; and 3) the value of a pregnancy loss when a cow became pregnant in MIM = 5 was: a) $221 when the loss was in first month in pregnancy and b) $897 when the loss was in the ninth month of pregnancy. The cow value indicated pregnant cows should be kept. The expected future production of a cow with respect to a similar average cow was an important determinant on the cow replacement decision. The expected production in the rest of the lactation was more important for nonpregnant cows and the expected production in successive lactation was more important for pregnant cows. A 120% expected milk production for a cow in MIM = 16 and 6 mo pregnant in the present lactation or in successive lactations determined between 1.52 and 6.48 times the cow value of an average production cow, respectively. The cow value decreased $211 for every 1 percentage point of expected genetic gain of the replacement. A breakeven analysis of the cow value with respect to expected milk production of an average second parity cow indicated that: 1) nonpregnant cows in MIM = 1 and 8 could still remain in the herd if they produce at least 84 and 98% in the present lactation or if they produce at least 78 and 97% in future lactations, respectively; and 2) cows becoming pregnant in MIM = 5 would require at least 64% of milk production in the rest of the lactation or 93% in successive lactations to remain in the herd.

Economics of resynchronization strategies including chemical tests to identify non-pregnant cows.

*Giordano, J. O., P, M. Fricke, and V. E. Cabrera. The objectives were to asses: 1) the economic value of decreasing the interval between timed AI (**TAI**) services when using a pregnancy test that allows earlier identification of nonpregnant cows; and 2) the impact of pregnancy loss and inaccuracy of a chemical test (**CT**) on the economic value of a pregnancy test for dairy farms. Simulation experiments were performed using a spreadsheet-based decision support tool (UW-DairyRepro$). In Experiment 1, the impact of changing the interbreeding interval (**IBI**) for cows receiving TAI on the value of reproductive programs was assessed by simulating a 1,000-cow dairy herd using a combination of detection of estrus (30 to 80% of cows detected in estrus) and TAI. The IBI was incremented by 7 d from 28 to 56 d to reflect intervals either observed (35 to 56) or potentially observed (28 d) in dairy operations. In Experiment 2, the impact of accuracy of the CT and additional pregnancy loss due to earlier testing on the value of reproductive programs was evaluated. The first scenario compared the use of a CT 31 ± 3 d after a previous AI with rectal palpation (**RP**) 39 ± 3 d after AI. The second scenario used a CT 24 ± 3 d after AI or transrectal ultrasound (**TU**) 32 d after AI. Parameters evaluated included: sensitivity (**Se**), specificity (**Sp**), questionable diagnosis (**Qd**), cost of the CT, and expected pregnancy loss. Sensitivity analysis was performed for all possible combinations of parameter values to determine their relative importance on the value of the CT. In Experiment 1, programs with a shorter IBI had greater economic net returns at all levels of detection of estrus, and use of chemical tests available in the market today might be beneficial when compared to RP. In Experiment 2, the economic value of programs using a CT could be either greater or lower than that of RP and TU depending on the value for each of the parameters related to the CT evaluated. The value of the program using the CT was affected (in order) by the 1) Se, 2) Sp, 3) pregnancy loss, 4) proportion of Qd, 5) the percent of cows AI in estrus, and 6) the CT cost. A change of 1% in the Se of the CT was 1.8 times more important than a similar change in Sp and pregnancy loss, and 13.7, 55.0, and 305.8 times more important than a similar change in Qd, cows inseminated in estrus, and the CT cost. We conclude that the major impact of using a CT was the potential of decreasing the IBI.*

Moreover, inaccuracy of the CT and additional pregnancy loss due to earlier testing resulted in smaller economic differences than when using RP or TU 8 d later.

Impact of animal density on predicted greenhouse gas emission on selected conventional, organic, and grazing dairy farms in Wisconsin.

Dutreuil, M., V. E. Cabrera, R. Gildersleeve, C. A. Hardie, and M. A. Wattiaux. The objective was to test the impact of animal density (AD) on predicted greenhouse gas emission (PGE) in three Wisconsin farms with contrasting management systems. A combination of farm data and model-based predictions, using the Integrated Farm System Model, was used to derive PGE on 1 conventional (C), 1 organic (O) and 1 grazing (G) farm at 2 AD. The farms had a herd size of about 80 cows, 133 ha of forage land, and 0.6 cows/ha. At this low AD (LAD), the PGE were 0.53, 0.70 and 0.77 kg of PGE (CO2eq)/kg of milk for the C, O and G respectively and the main source of PGE was from housing facilities (47, 39, and 31% of total PGE on C, Oand G, respectively). The indirect emission sources (manufacture or production of fuel, electricity, machinery, fertilizer, pesticide, and plastic) accounted for 21, 12, and 30% of PGE on C, O and G, respectively. Other important PGE sources at LAD were feed production on C (19%), and grazing on O and G (35 and 14%, respectively). Doubling the AD (HAD, 1.2 cows/ha of forage land) increased PGE by 22.9% on C, mainly due to 48% increase from indirect sources. The emissions from feed production and indirect sources increased by 38 and 29%, respectively on O, but the emission from grazing and housing facilities decreased by 5 and 1.3%, respectively, which led to a 6.4% net increase. Finally, PGE decreased by 3.1% on G as the net result of a decrease in emissions from manure storage and fuel consumption (41 and 20%, respectively) but 8% increase in indirect sources. These results demonstrated that the impact of AD on PGE was different on the 3 selected farms because of different farm management practices such as feeding, manure storage, and housing facilities. Although increasing AD might have a beneficial effect in reducing PGE per unit of milk on the selected G farm, results predicted a slight negative effect in the O farm and a more substantial negative effect on the C farm. Although the scope of the study is limited to the 3 selected farms, combining farm data with model-based predictions may be useful to study the changes in farm-level management practices on PGE.

A cluster analysis to describe profitability on Wisconsin dairy farms.

Dutreuil, M., V. E. Cabrera, R. Gildersleeve, C. A. Hardie, and M. A. Wattiaux. A survey was implemented on Wisconsin dairy farms to understand the impact of farm management on profitability. Farms were selected across 3 systems: conventional (C), grazing (G) and organic (O). The objective was to characterize main factors associated with profitability. A cluster analysis using complete linkage was conducted on 20 farms as preliminary analysis: 4 O, 4 G and 12 C. The analysis yielded 3 clusters. Cluster 1 included 1 O, 2 G and 6 C farms; cluster 2 included 4 C and 1 G farms; and cluster 3 included 3 O, 1 G and 2 C farms. Clusters 1 and 3 had the same income over feed cost (IOFC, $5.97 and $5.22/d per cow, respectively) whereas cluster 2 had an IOFC of $8.09/d per cow. Farms in cluster 2 had 71 cows and 95 ha and were managed by the youngest farmers (44 years old). They used a ration with 35% grass silage (GS), 1% hay, 18% corn silage (CS) and 46% concentrate (C). They had the greatest milk production (10,764 kg/cow per year) and the lowest percentage of milk withheld from sale (0.49%). They produced milk with 3.55% fat, 3.03% protein and 203,000 somatic cells (SCC), but received the lowest milk price (0.348$/kg). Farms in cluster 1 had 72 cows and 115 ha and were managed by 49 years old farmers. They used 20% GS, 32% hay, 12% CS and 36% C in the ration. They had a lower milk production (7,068 kg/cow per year) and more milk withheld (1.65%) than farms in cluster 2. Their

milk had 3.78% fat and 2.99% protein with a price of 0.368$/kg. Farms in cluster 3 were the smallest farms with 48 cows and 54 ha and were managed by 49 years old farmers. They used 17% GS, 54% hay, 5% CS and 24% C in the ration. They produced the least amount of milk (4,146kg/cow per year) and withheld 3.08% of production. They had the greatest milk fat and protein content (4.36% and 3.25%, respectively), the greatest SCC (317,167) and the greatest milk price (0.480$/kg). The 3 clusters contained farms from different systems indicating that management system was not a major descriptor of IOFC. However, this study suggested that IOFC was associated with quantity and quality of milk, percentage of milk withheld, feeding strategy and age of the farmer.

E. PUBLICATIONS:

Peer-reviewed research and extension.

Giordano, J. O., P. M. Fricke, M. C. Wiltbank, and V. E. Cabrera. 2011. An economic decision-making decision support system for selection of reproductive management programs on dairy farms. *Journal of Dairy Science* 94:6216-6232.

Kalantari, A. S., and V. E. Cabrera. 2012. The effect of reproductive performance on the dairy cattle herd value assessed by integrating a daily dynamic programming with a daily Markov chain model. *Journal of Dairy Science* 00:00-00. *In Press.*

Giordano, J. O., A. Kalantari, P. M. Fricke, M. C. Wiltbank, and V. E. Cabrera. 2012. A daily herd Markov-chain model to study the reproductive and economic impact of reproductive programs combining timed artificial insemination and estrous detection. *Journal of Dairy Science* 95:5442–5460.

Cabrera, V. E. 2012. A simple formulation and solution to the replacement problem: A practical tool to assess the economic cow value, the value of a new pregnancy, and the cost of a pregnancy loss. *Journal of Dairy Science* 95:4683-4698.

Giordano, J. O., P. M. Fricke, and V. E. Cabrera. *Accepted*. Economics of resynchronization strategies including chemical tests to identify non-pregnant cows. *Journal of Dairy Science* 00:00-00.

Dutreuil, M., V. E. Cabrera, R. Gildersleeve, C. A. Hardie, and M. A. Wattiaux. 2012. Impact of animal density on predicted greenhouse gas emission on selected conventional, organic, and grazing dairy farms in Wisconsin. *Journal of Animal Science* 00 (E-Suppl. 1):00.

Kalantari, A. S., and V. E. Cabrera. 2012. The effect of reproductive performance on the herd value assessed by integrating a daily dynamic programming with a daily Markov chain model. *Journal of Animal Science* 00 (E-Suppl. 1):00.

Dutreuil, M., V. E. Cabrera, R. Gildersleeve, C. A. Hardie, and M. A. Wattiaux. 2012. A cluster analysis to describe profitability on Wisconsin dairy farms. *Journal of Animal Science* 00 (E-Suppl. 1):00.

Cordoba, M. C., P. M. Fricke, P. L. Ruegg, R. D. Shaver, K. A Weigel, and V. E. Cabrera. 2012. Repro Money: A farmer directed team-based extension program to improve reproductive performance in Wisconsin dairy herds. J. Anim. Sci. 00 (E-Suppl. 1):00.

Hardie, C. A., V. E. Cabrera, M. Dutreuil, R. Gildersleeve, and M. Wattiaux. 2012. Characterization of certified organic Wisconsin dairy farms: Management practices, feeding regimes, and milk production. *Journal of Animal Science* 00 (E-Suppl. 1):00.

Cabrera, V. E. 2012. DairyMGT: A suite of decision support systems in dairy farm management. IN Decision Support Systems. Jao C. (Ed.), INTECH, Rijeka, Croatia. Describes the development, dissemination, and impacts of decision support systems contained in the DairyMGT.info Website developed as part of my extension program. *In press.*

Dutreuil, M., Gildersleeve, R., and V. E. Cabrera. 2012. Dealing with high feed cost: Supplementation on pasture. In Proceedings *4th Annual World Dairy Expo Grazing Seminars*. Alliant Energy Center, Madison, WI. 5 October 2012.

Hardie, C. A., V. E. Cabrera, M. Dutreuil, and R. Gildersleeve. 2012. Characterization of certified organic Wisconsin dairy farms: Management practices, feeding regimes, and milk production. In Proceedings *UW-Extension Grazing, Teaching, and Technology Conference*. US Dairy Forage Research Center, Prairie du Sac, WI. 28 August 2012.

Dutreuil, M., V. E. Cabrera, R. Gildersleeve, and C. A. Hardie. 2012. Factors affecting profitability on Wisconsin dairy farms. In Proceedings *UW-Extension Grazing, Teaching, and Technology Conference*. US Dairy Forage Research Center, Prairie du Sac, WI. 28 August 2012.

Cabrera, V. E., F. Contreras, R. D. Shaver, L. E. Armentano. 2012. Grouping strategies for feeding lactating dairy cattle. Pp. 40-44 in Proceedings Four-State Dairy Nutrition and Management Conference. Dubuque, IA, 13-14 June 2012.

Cabrera, V. E., Giordano, J., Fricke, P. 2011. Economics of resynchronization with chemical tests to identify non-pregnant cows. Pp. 57-67 in Proceedings Dairy Cattle Reproduction Council Annual Convention. Kansas City, MO, 10-11 November 2011.

Decision Support Tools:

Cabrera, V. E. 2012. The economic value of a dairy cow. *Calculates the value of a dairy cow and helps in the decision of keeping or replacing a cow. Online application. Also available as a Spreadsheet application. Video demonstration (6:27 minutes).*

Cabrera, V. E., L. Armentano, and R. D. Shaver. 2012. FeedVal 2012. *Estimates the market value of dairy feed ingredients. Online application.*

Cabrera, V. E., and J. O. Giordano. 2012. UW-DairyRepro$Plus: A reproductive analysis tool that includes heat detection devices. *An update of the UW-DairyRepro$ tool that has improved design and it is capable of analyzing the use of heat detection devices within defined reproductive programs in dairy cattle. Spreadsheet application.*

Cabrera, V. E. 2011. Dairy reproductive economic analysis. *Simulates a dairy herd and their replacements to evaluate the impact of improved reproductive efficiency in dairy cattle. Online application. Video demonstration (7:36 minutes).*

F. IMPACT STATEMENT (in lay language for government agencies and elected representatives)

Dairy producers in Wisconsin and elsewhere are always looking for cost-efficient and profitable management strategies to improve their bottom-line and guarantee their long-term economic and environmental sustainability. Dairy producers have indicated that they need support in making complex planning decisions to improve their efficiency of production, profitability, and for the dairy industry to remain sustainable. Management information systems are increasingly important for helping in the decision-making of dairy systems. Indeed, dairy farming is a decision-intensive enterprise where profitable decisions cannot be made without the use of decision aids. The dynamics of dairy farm systems warrants the utilization of sophisticated techniques to assess the impacts of management strategies to farm economics, which at the same time need to be user-friendly and ready to be applied at the farm level. Simulation techniques help to overcome these shortcomings assessing cost-efficiency and profitability even under highly uncertain scenarios. Wisconsin's applied research and extension programs are committed to provide relevant, up-to-date, research based, and field-tested decision aids to farmers, extension agents.

G. LEVERAGE (*dollars and other resources – because of your work in this project you've been able to leverage resources from what other sources, amounts?***):**

Bravo-Ureta, B. (PD), A. De Vries, A., R. Mosheim, and V. E. Cabrera. 2012-2016. Interaction between productivity growth and environmental factors for multi-output farms with a dairy focus. USDA National Institute of Food and Agriculture, Agriculture and Food Research Initiative Competitive Grant Programs: Agriculture Economics and Rural Communities. $318,000.

VandeHaar, M. (PD), K. A. Weigel, L. E. Armentano (WI-PD), D. Moody Spurlock, R. Tempelman, R. Veerkamp, V. E. Cabrera, M. Worku, M. Hanigan, C. Staples, D. Beede, R. D. Shaver, M. A. Wattiaux, J. Dijkstra, R. Pursley, and M. Weber Nielsen. 2011-2016. Genomic selection and herd management tools to improve feed efficiency of the dairy industry. USDA National Institute of Food and Agriculture, Agriculture and Food Research Initiative Competitive Grants Program: Improving Sustainability by Improving Feed Efficiency of Animals. $5,000,000.

Cabrera, V. E. (PD), P. M. Fricke, P. L. Ruegg, R. D. Shaver, K. A. Weigel, and M. C. Wiltbank. 2010-2014. An integrated approach to improving dairy cow fertility. USDA National Institute of Food and Agriculture, Agriculture and Food Research Initiative Competitive Grants Program: Integrated Solutions for Animal Agriculture. $1,000,000.

Cabrera, V. E. (PD), R. R. Gildersleeve, M. A. Wattiaux, and D. K. Combs. 2010-2014. Strategies of pasture supplementation on organic and conventional grazing dairies: Assessment of economic, production and environmental outcomes. USDA National Institute of Food and Agriculture Organic Agriculture Research and Extension Initiative. $575,000.

V. E. Cabrera. 2011-2013. Development of a suite of dairy reproduction decision support tools. USDA Hatch Multistate Single Investigator. $83,000.

Gould, B. W., and V. E. Cabrera. (Co-PDs). 2011-2013. Delivery of educational materials to increase LGM-Dairy utilization by dairy farm operators in general and limited resource operators. USDA Risk Management Education and Outreach Partnership Program, Competitive Cooperative Partnership Agreements. $86,000.

Nienhuis, J. (PD), V. E. Cabrera, and international partners. 2011-2013. Seeds of Hope. US Agency for International Development. $186,000.

Wattiaux, M. A. (PD), B. Barham, M. Bell, V. E. Cabrera, and J. Harrison Pritkin. 2009-2013. Integrated analysis of diverse dairy systems in Mexico and Wisconsin: Building capacity for multidisciplinary appraisal of sustainability. USDA National Institute of Food and Agriculture International Science and Education Grants Program. $150,000.