# NC 1042: 2010- 2011 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:**

***An economic decision-making support system for selection of reproductive management programs on dairy farms.***

*Giordano, J., P. M. Fricke, M. C. Wiltbank, and V. E. Cabrera. Because the reproductive performance of lactating dairy cows influences the profitability of dairy operations, predicting the future reproductive and economic performance of dairy herds through decision support systems would be valuable to dairy producers and consultants. In this study, we present a highly adaptable tool created based on a mathematical model combining Markov chain simulation with partial budgeting to obtain the net present value (NPV; $/cow/yr) of different reproductive management programs. The growing complexity of reproductive programs used by dairy farms demands that new decision support systems precisely reflect the events that occur on the farm. Therefore, the model requires productive, reproductive, and economic input data used for simulation of farm conditions to account for all factors related to reproductive management that increase costs and generate revenue. The economic performance of three different reproductive programs can be simultaneously compared with the current model. A program utilizing 100% visual estrous detection (ED) for AI is used as baseline for comparison to two other programs that may include 100% timed AI (TAI) as well as any combination of TAI and ED. A case study is presented in which the model was used to compare three different reproductive management strategies (100% ED baseline vs. two 100% TAI options) using data from a commercial farm in Wisconsin. Sensitivity analysis was then used to assess the impact of varying specific reproductive parameters on the NPV. Under the simulated conditions of the case study, the model indicated that: the two 100% TAI programs were superior to the 100% ED program and among the 100% TAI programs the one with higher conception rate (CR) for resynchronized AI services was economically superior in spite of higher costs and having a longer interbreeding interval. A 4% increase for resynchronized AI was sufficient for the inferior 100% TAI to outperform the superior program. Adding ED to the 100% TAI programs was only beneficial for the program with lower CR. The improvement in service rate required for the 100% ED program to have the same NPV as the superior 100% TAI program was 12%. The decision support system developed in this study is a valuable tool that may be used to assist dairy producers and industry consultants in selecting the farm-specific best reproductive management strategy.*

***Decision tree analysis of treatment strategies for mild and moderate cases of clinical mastitis occurring in early lactation.***

*C. Pinzón-Sánchez, V. E. Cabrera, and P. L. Ruegg. The objective of this study was to develop a decision tree to evaluate the economic impact of different durations of intramammary treatment for the first case of mild or moderate clinical mastitis (CM) occurring in early lactation with various scenarios of pathogen distributions and variable use of on-farm culture.  The first decision node in*

the tree evaluated use of on-farm culture (OFC) (two programs using OFC and one not using OFC) and the second decision evaluated treatment strategies (no intramammary antimicrobials or antimicrobials administered for 2, 5 or 8d). The tree included probabilities for realistic distributions of etiologies, bacteriological cure and recurrence. The economic consequences of mastitis included costs of diagnosis and initial treatment, additional treatments, labor, discarded milk, milk production losses due to clinical and subclinical mastitis, culling and transmission of infection to other cows (only for CM caused by S. aureus). Pathogen specific estimates for bacteriological cure and milk losses were used. The economically optimal path for several scenarios was determined by comparison of expected monetary values. For most scenarios, the optimal economic strategy was to treat CM caused by Gram-positive pathogens for 2 days and to avoid antimicrobials for CM cases caused by Gram-negative pathogens or when no pathogen was recovered. Use of extended intramammary antimicrobial therapy resulted in the least expected monetary values.

### 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 of this study was to compare the economic and reproductive performance of programs combining timed AI (TAI) and different levels of AI after estrous detection (ED) using a daily Markov-chain model. A dairy herd was modeled with every cow following daily probabilistic events of aging, culling, mortality, pregnancy, pregnancy loss, and calving. All non-pregnant cows had a probability of pregnancy between the end of the VWP and a DIM cutoff for AI. After the cutoff, cows were labeled as "do-not-breed" and culled when milk production was below a minimum milk threshold. An algorithm was iterated until the proportion of cows in each state remained unchanged (steady state). A similar model was created to represent a heifer replacement 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), culling 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 AI after ED increased, the CR of cows receiving TAI decreased. Overall, the combined programs with CR of 35% for cows 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 AI after ED and 30% CR. The factor with the greatest relative contribution to the differences between programs was IOFC followed by culling and reproductive costs. Adjusting the DIM 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 AI after ED and the resulting CR. The impact of adjusting heifer supply and demand on the NV of programs depended on the heifer balance with the original DIM cutoff for AI.*

### Revenue risk management, risk aversion and the use of livestock gross margin for dairy cattle insurance

*Valvekar, M, J. P. Chavas, B. W. Gould, and V. E. Cabrera. The Livestock Gross Margin Insurance for Dairy Cattle is a federally reinsured insurance program that enables U.S. dairy producers to establish minimum levels of milk income net of feed cost. Given the structure of this program there are an infinite number of possible contract designs based on the choice of deductible level and proportion of production insured. Adding to this complexity, producers vary in their risk preferences, which affect the incentive to insure their margin. It is unclear as to how producers may adopt this program for revenue risk management. This paper investigates the interplay between producer risk preferences, contract design and the subsidization of premium in determining program coverage. We undertook this analysis within an expected utility framework. Optimal contracts under different rates of constant relative rate of risk aversion and subsidies were analyzed using a nonlinear optimization model. We found that total optimal coverage increased significantly with the level of risk of aversion at lower deductibles but as deductible level increased, the level of risk aversion had a lesser impact on total optimal coverages. As expected, at the same deductible and risk aversion levels, inclusion of a premium subsidy increased the total optimal coverage.*

### Analyzing the sources of technical efficiency among heterogeneous dairy farms: A quantile regression approach.

*Chidmi, B., D. Solís, and V. E. Cabrera. An unbalanced panel data including 1,151 farm observations from 2004 to 2008 was used to analyze the determinants of technical efficiency (TE) for dairy farms in the State of Wisconsin. To account for farm heterogeneity a two-step framework was implemented using a stochastic production frontier and a quantile regression analysis. The results show that the determinants of TE affect in very specific ways farmers with different levels of TE. This outcome is of significant importance from an empirical point of view. Farmers could use this knowledge to find alternatives to improve their specific level of performance. Additionally, Policy makers could use this information to improve the effectiveness of their policies by targeting specific agricultural services and aid to group of farmers with similar levels of TE.*

### Linear programming for dairy herd simulation and optimization: An integrated approach for decision-making.

*Cabrera, V. E., and P. E. Hildebrand. The use of linear programming (LP) in farming systems is not a new concept. Linear programming has been used extensively to suggest the impact of alternative management practices at the whole farm level. Although these applications included livestock practices, there have not been many studies that formally and systematically investigated dairy herd systems. Linear programming can be a powerful tool to simulate and optimize the dairy herd system inside a Markov-chain structure. On the other hand, the concept of dynamic programming (DP) for a dairy herd has long been recognized and used to find optimal policies for dairy herd management. Various options have been analyzed to find optimal replacement policies, reproductive parameters, and feeding strategies in dairy herds by using value or policy iteration methods. However, even though the formulation has been available since the 1980s, the solution of DP using LP has not been widely explored probably because the computer and software systems did not support the solution of real and practical problems. The formulation of DP as an LP problem for real, but large problems is now feasible and has substantial advantages over other methods because it allows the inclusion of the interaction of herd mates, solving for sub-optimal conditions, controlling efficiently for the time steps of the analysis, and uses standard LP algorithms for solution. In the present chapter we discuss the application of LP in dairy herd management to solve DP problems and to propose stochastic*

simulation and optimization in a Markov-chain structure for decision-making in modern dairy herd management.

**Impact of feeding strategies on milk production and income over feed cost: a case study of organic, grazing and conventional Wisconsin dairy farms.**

*Dutreuil, M., M. Wattiaux, R. Gildersleeve, B. Barham, and V. E. Cabrera. A survey was developed to understand feeding practices on Wisconsin dairy farms and their consequences on milk production and milk income over feed cost (IOFC). Farms were randomly selected across 3 management systems: conventional (CON), grazing (GRA) and organic (ORG). Preliminary results from 2 CON, 3 GRA and 3 ORG are presented. No statistical analysis is reported because of these small numbers of farms. Grains were used in similar amounts across the year 2010 on GRA and ORG, whereas CON used less than half grain in summer than in winter. Grains were partially replaced in CON by a protein mix that was used more than double in summer than in winter. Hay was the main component in the winter for all the farm systems, which was partially replaced by grazing during summer. Corn silage, haylage, and baleage were used in similar amounts throughout the year by CON and ORG, whereas GRA used an additional 3.9 kg DM/cow/d in summer. In total, DMI in winter (kg/cow/d) was higher for CON and GRA (24.6 and 23.8, respectively) than for ORG (15.0), which led to differences in milk production (kg/cow/d) and cost of feed, ($/cow/d) for CON (27.3 and 2.6), GRA (20.0 and 1.5), and ORG (10.4 and 1.5). Milk price for ORG ($60/100 kg milk) was about twice as much as CON and GRA. Calculated milk IOFC ($/cow/d) was higher for CON (6.8) in winter and for ORG (7.5) in summer. The use of grazing by ORG during summer improved milk production (+4.6 kg/cow/day) and decreased feed cost (-0.2 $/cow/day), which determined the highest milk IOFC. Our preliminary results indicate that, given 2010 prices, ORG could be as much profitable as CON or GRA systems when including the USDA's National Organic Program grazing standards.*

**Wisconsin dairy business and production survey: Comparison between farms planning to expand and farms not planning to expand**

*Cabrera, V. E., Janowski, J. M. The survey was conducted to provide a comprehensive assessment of Wisconsin dairy operations. Key differences between expanding and non-expanding dairies were highlighted with additional focus on topics involving dairy expansion. Further priority was placed on maximizing the impact of a concurrent project concerning risk management in dairy production and expansion. Survey results highlight emerging trends among Wisconsin dairy farms and emphasize areas where further research and outreach programs are needed.*

**Genomic selection and herd management tools to improve feed efficiency of the dairy industry.**

*Genomic dairy data collection has started. UW-Madison has hired a technician to compile information in a database, to collaborate in the diffusion of extension messages, and to support some of the instructional objectives. As an extension component, a decision support tool has been created (dairy feeding grouping strategy) and currently is being re-fined and used for demonstration with dairy farms and dairy farm consultants. The tool demonstrates the economic advantage of feeding more than a diet to lactating cows.*

*An integrated approach to improving dairy cow fertility*

*Cabrera, V.E., P. M. Fricke, R. Shaver, P. Ruegg, K. Weigel, and M. Wiltbank. Important progress has been made regarding 1) the economic evaluation of reproductive programs and the value of improving reproductive efficiency and 2) the overarching objective to enroll farms in the created ReproMoney extension program. All other objectives are under development: 1) Database mining and machine learning algorithms, 2) mastitis and reproduction, and 3) nutrition and reproduction.*

*The impact of feed supplementation in grazing dairy systems*

*Cabrera, V.E., R. Gildersleeve, M. Wattiaux, and D. Combs. Currently more than 70 dairy farms have been visited and enrolled in the study. In each of them a large survey was applied (normally lasting > 4 hours) to collect detailed information regarding management practices for dairy herd, crops, manure management, and other 10 areas of interest. Interviews will continue to the end of 2011. Two students are making the data collection together with the database entry. A series of frameworks are being considered for data analyses including: principal component analysis, whole farm simulation frameworks, sustainability indicators (IDEA), etc.*

## 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 support system for selection of reproductive management programs on dairy farms. J. Dairy Sci. (*in press*).

Valvekar, M., J. P. Chavas, B. W. Gould, and V. E. Cabrera. 2011. Revenue risk management, risk aversion and the use of Livestock Gross Margin for Dairy Cattle insurance. Ag. Systems 104:671-678.

Chidmi, B., D. Solís and V. E. Cabrera. 2011. Analyzing the sources of technical efficiency among heterogeneous dairy farms: A quantile regression approach. Journal of Development and Agricultural Economics 3(7): 318–324.

Pinzón-Sánchez, C., V. E. Cabrera and P.L. Ruegg. 2011. Decision tree analysis of treatment strategies for mild and moderate cases of clinical mastitis. Journal of Dairy Sci. 94:1873-1892.

Cabrera, V. E., and P. E. Hildebrand. 2011. Chapter7: Linear programming for dairy herd simulation and optimization: An integrated approach for decision-making. IN Linear Programming - new frontiers and applications. Zoltan, A. M. (Eds), Nova Science Publishers, Inc, Hauppauge, NY.

Cabrera, V.E., Janowski, J.M. 2011. Wisconsin dairy business and production survey: Comparison between farms planning to expand and farms not planning to expand. Journal of Extension 3RIB1 (http://www.joe.org/joe/2011june/rb1.php).

Breuer, N.E., Fraisse, C.W., Cabrera, V.E. 2010. The Cooperative Extension Service as a boundary organization for diffusion of climate forecast: A 5-year study. Journal of Extension 4RIB7 (http://www.joe.org/joe/2010august/rb7.php).

Breuer, N.E., Cabrera, V.E., Hildebrand, P.E., and J.W. Jones. 2010. Opciones de manejo basadas en el clima para productores de ganado vacuno en el centro-norte de Florida. EDIS-University of Florida. (http://edis.ifas.ufl.edu/ae468).

Valvekar, M., Cabrera, V.E., Gould, B.W. 2010. Identifying optimal strategies for guaranteeing target dairy income over feed cost. Journal of Dairy Science 93:3350-3357.

Cabrera, V.E. 2010. A large Markovian linear program for replacement policies to optimize dairy herd net income for diets and nitrogen excretion. Journal of Dairy Science 93:394-406.

Cabrera, V.E., Solis, D., del Corral, J. 2010. Determinants of Technical Efficiency among Dairy Farms in Wisconsin. Journal of Dairy Science 93:387-393.

Inostroza, J.F., Shaver, R.D., Cabrera, V.E., and Tricarico, J.M. 2010. Effect of diets containing a controlled-release urea product on milk yield, composition and component yields in commercial Wisconsin dairy herds and economic implications. Professional Animal Scientist 26:175-180.

**Non-peer reviewed (e.g., proceedings articles, abstracts, articles for client and lay audiences:**

Cabrera, V. E. 2011. The need for applied research and decision support tools in dairy farm management and decision-making. Dairy Sci. 2011 ADSA Meeting. ADSA Foundation Scholar Award in Dairy Production. (Invited).

Cabrera, V. E. 2011. Exploring methods to assess the economic value of dairy cattle reproductive programs. J. Dairy Sci. 66 (E-Suppl. 3):26. (Invited).

Cabrera, V. E. 2011. The economic value of changes in 21-day pregnancy rate and what controls this value. 21st ADSA Discover Conference: Improving reproductive efficiency of lactating dairy cows. (Invited).

Cabrera, V. E. 2011. Timed artificial insemination with or without estrous detection. 21st ADSA Discover Conference: Improving reproductive efficiency of lactating dairy cows. (Invited).

Pinzón-Sánchez, C., V. E. Cabrera, and P. L. Ruegg. 2011. Decision tree analysis treatment strategies for mild and moderate cases of clinical mastitis occurring in early lactation. 2011 American Association of Bovine Practitioners Meeting, St. Louis.

Giordano, J. O., P. M. Fricke, M. C. Wiltbank. 2011. Daily Markov-chain simulation model for selection of reproductive programs in dairy herds. J. Dairy Sci. 2011 ADSA Meeting.

Dutreuil, M., M. Wattiaux, R. Gildersleeve, B. Barham, and V. E. Cabrera. 2011. Impact of feeding strategies on milk production and income over feed cost: a case study of organic, grazing and conventional Wisconsin dairy farms. Dairy Sci. 2011 ADSA Meeting.

Souza, A. H., H. Rivera, V. E. Cabrera, P. Crump, and M. C. Wiltbank. 2011. Estimating field conception rates for Holstein sires in US herds (ACE index) and conception rate correlation from the same sires used for AI after natural estrus and timed AI breedings. Dairy Sci. 2011 ADSA Meeting.

Giordano, J. O., A. S. Kalantari, and V. E. Cabrera. 2011. Economic reproductive outcome of programs combining timed artificial insemination and estrous detection with a daily Markov-chain

model. 21st ADSA Discover Conference: Improving reproductive efficiency of lactating dairy cows.

**Decision Support Tools:**

Cabrera, V. E., R. Shaver, L. Armentano, D. Beede. Grouping cows for feeding to improve dairy farm profitability.

Kalantari, A. S., V. E. Cabrera. 2011. Milk curve fitter.

Cabrera, V. E., P. Meyer. Projecting Dairy herd size and make-up using the herd structure simulation model.

Cabrera, V. E. 2010. Dairy reproductive economic analysis: assessing the value of improving reproductive efficiency.

Cabrera, V. E. 2010. Exploring timing of pregnancy impact on income over feed cost.

Bolton, K., V. E. Cabrera. 2011. Working capital: A tool to planning for the next swing in milk price.


**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.*

*Our 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?***):**

USDA-AFRI-ERS. 2012-2015. Interaction between productivity growth and environmental factors for multi-output farms with a dairy focus. Bravo-Ureta, A. De Vries, R. Mosheim, V. E. Cabrera.

$5,000,000. 2011-2016. USDA Agriculture and Food Research Initiative. Genomic Selection and Herd Management Tools to Improve Feed Efficiency of the Dairy Industry. Van de Haar, M.

(Michigan State University, PI), Cabrera, V.E., and other 14 in distinct U.S. and European universities. ACTIVE.

$1,000,000. 03/15/10-03/14/14. An integrated approach to improving dairy cow fertility. Cabrera, V.E. (PI), Fricke, P., Shaver, R., Ruegg, P., Weigel, K, Wiltbank, M. ACTIVE.

$574,621. 01/15/10-01/14/14. USDA Organic Research and Education Initiative. Strategies of Pasture Supplementation on Organic and Conventional Grazing Dairies: Assessment of Economic, Production and Environmental Outcomes. Cabrera, V.E. (PI), Gildersleeve, R., Wattiaux, M., Combs, D. ACTIVE.

$150,000. 09/01/09-08/31/13. USDA International Science and Education (ISE) Competitive Grant Program. Integrated Analysis of Diverse Dairy Systems in Mexico and Wisconsin: Building Capacity for Multidisciplinary Appraisal of Sustainability. Wattiaux, M. (PI), Barham, B., Bell, M., Cabrera, V.E., Harrison Pritkin, J. ACTIVE.

$83,000. 10/01/11-09/30/13. USDA Hatch Funding. Development of a suite of dairy reproduction decision support tools. Cabrera, V.E. ACTIVE.

$76,000. 06/30/10 to 09/30/12. Energy Intensity, Carbon Footprint and Environmental Impact of Pasture based Dairy. Grazing Lands Conservation Initiative Grants. Reinemann, D.J. (PI), Cabrera, V.E. ACTIVE.

$47,000. 07/01/10 to 12/31/11. USDA North Central Risk Management Education Center. A sustainable Wisconsin dairy farm financial management model. Bolton, K., Cabrera, V.E. (co-PIs). ACTIVE.