Key Performance Monitoring of Dairies

Jim Barmore, M.Sc., PAS
Five-Star Dairy Consulting, LLC
Verona, WI

Key Take Home Message: When performance is measured and reported back to managers and employees in a timely fashion, improvements happen quicker. Key performance monitoring looks daily at the areas critical to the success and financial health of a dairy including the areas of nutrition, health, fresh cows, reproduction, parlor performance, and financials.

Introduction

On many dairies, the managers or employees don't fully understand or appreciate the impact their role has on the overall profitability and success of the dairy. Take for example a lead feeder or the feed manager who is responsible for handling over 50% of the variable costs of the dairy which can account for well over $1,000,000 of feed value for dairies larger than 1000 cows, and often equipment worth several thousands of dollars. To help improve employee performance, many dairies make efforts to collect and report data, but yet still struggle with getting better consistency and performance from employees. Why is this?

Dairies many times don't lack data, rather they have an over-abundance of data that isn't organized, properly interpreted, communicated back to employees, acted upon, or possibly isn't even good data being collected initially. Employees quickly realize when there isn't proper accountability and use of the data being collected, so they like others on the team fall off on follow-thru and compliance of collecting and entering data. Experience has shown that by gaining the interest and cooperation of on-farm employees and management to engage in daily monitoring, the success of a dairy improves.

Clearly, making improvements to existing management practices first requires good timely data and information that can be regularly collected and interpreted at the farm daily. There is a big need to simplify monitoring, looking primarily at parameters that can be readily collected and that have the most financial impact on the dairy.

The concept of performance monitoring isn't new, but many past discussions have centered on monthly, quarterly or even annual measurements with much of the interpretation done by outside advisors such as a nutritionist, veterinarian, lender, extension, and other consultants. There are examples of real success and progress in monitoring such as the area of reproductive programs, much through the leadership and efforts of veterinarians. Intake and moisture monitoring of feeding has also improved.

Barmore, (608) 833-1552, FAX (608) 833-1035, Email: fivestardairy@charter.net

Although of some value, monthly or other periodic performance monitoring does not usually sufficiently provide the timeliness of good daily information to optimize the management of a dairy. Simply, there is too much time lag in much of the monitoring being used.

Key performance monitoring is really about reducing variation, with variation being the opposite of consistency. While the idea of consistency is intuitive among good dairy managers, study of herds indicates there is a great amount of process variation found on dairy farms today. Why? People, cows, and weather are all biological based that inherently have a fair amount of associated variation. Establishing consistency, which cows thrive on, while minimizing variation requires understanding not only the mean or averages of the data, but also the amount of variation associated with tasks and outcomes at dairies. It was well said by W.E. Deming, famous for his teaching of process control and improvement, *"if I had to reduce my message to management to just a few words, I'd say it all has to do with reducing variation". – W.E. Deming.*

Monitors vs. Report Card

As an industry, the computer is used to process and calculate a wealth of data that pertains to dairies. From this, the industry has many benchmarks, and typically provides "report card" that suggest past success or failure. In general, report cards do little to predict future outcomes, and more importantly often are associated with time lag and are too slow to let us know there is a serious problem. Aggressive and successful businesses are more interested in where they are going rather than where they have been.
Our industry is overloaded with benchmarks that show past performance and historical perspective, and this is assuming the benchmarks have equal numerators and denominators to allow fair comparisons across dairies.

Benchmarking ***within*** a dairy can have real value, benchmarking across dairies is often over-interpreted and mis-used. Although benchmarks and report cards certainly have some value, they do not necessarily provide meaningful information to help a dairy navigate and improve the business over the upcoming days, weeks and months.

As opposed to a report card, the industry needs to develop "***monitors***" to assess dairy performance. What does the word "monitor" mean as applied to dairy records? As a verb, it means the process of tracking parameters to detect change or lack of progress. As a noun, it is a specific parameter that is routinely measured. Why should we monitor records on a dairy or heifer operation? There are 4 key reasons to monitor:

1. Detect an undesirable trend or outcome with minimal time lag
2. Evaluate the impact of a management change
3. Motivate, teach, and implement needed change
4. Track parameters with greatest impact on financial success

Management changes can include milk procedure changes, feeding changes, grouping changes, environment changes, etc. Before any management change is implemented, the dairy should know how to evaluate the response. The dairy should have knowledge of past performance and the ability to measure future performance with the appropriate parameter, with a clear understanding of both the average or mean performance, but even more importantly the distribution of performance being monitored across different seasons of the year.

It is important that questions are asked first before data is collected and monitoring begins. For example, a question may be: "is fertility in my herd declining this summer?" Which parameter(s) would appropriately answer this question? It makes little sense to monitor a parameter and then decide what questions it may answer.

Monitoring requires time and effort. Someone must collect the data, and then the data must be entered, analyzed and interpreted. Preferably, the person collecting and entering data is the manager most invested in the outcome of a particular area of the dairy. An example might be fresh cow monitoring would be recorded and entered by the person doing the fresh cow checks. Seems obvious, but this doesn't always happen. If this process does not result in discussion and/or action, then why bother? Indeed, the goal of monitoring is to establish when "real" change has occurred due some change in the process, rather than change occurring due to random normal acceptable variation. The basis of monitoring is to better understand variation around specific outcomes, and then refining changes in training or protocols when the process is outside normal variation. Training and retraining is a key component of performance monitoring.

Fuhrmann (2007) has identified these key steps to performance monitoring: 1) timely collection of data, including organizing and interpretation of the data, 2) adjusting protocols as needed or establishing protocols, and 3) proper training of the right people to implement the protocol. Monitoring is wasted effort if decisions or appropriate management interventions do not result.

In summary, monitors should:

1. be proactive
2. be readily measurable and involve key employees and middle managers
3. impact improvement and profit
4. minimize variation, bias, lag, and momentum
5. result in discussion and action

Currently there are several tools being used to store and collect data on-farm that are valuable, including feed scale management programs, milk meters and parlor programs, Dairy Comp 305, spreadsheets, palm pilots, and others. The challenge with these programs is the data is often not well organized and/or reported on a routine basis, which is a key step to proper interpretation of the data. Getting on-farm managers more involved in performance monitoring has been successful, and often requires that preprinted forms are used to collect data daily from the key areas of the dairy such as fresh cows.

Monitoring & Data Interpretation

The computer has created a world that is overwhelmed with information and data, yet often there isn't a clear understanding of how to properly collect, organize, and interpret good data. As the saying goes, "success comes from not what we know, but what we do with what we know".

Before deciding to collect "more data", these three steps are recommended:

1. Clearly define what you are trying to measure, specifically defining the numerator and denominator if a calculation is involved. Think about this one!
2. The need is for "good" data versus "more" data; good data only can be generated if it's easily compiled, actually is the proper data for the question being addressed, and is timely which often means daily.
3. There must be appropriate interpretation and discussion of the data, in a timely fashion, with the appropriate employees and advisors having agreement on management adjustments that will be taken because of the data interpretation.

There are several important principles of data interpretation and performance monitoring that must be considered to minimize misinterpretation of the data. Specifically to managing a dairy, the phrase "numbers don't lie" might be better rephrased as "numbers don't lie if properly interpreted in the context of normal biological and process variation, and they are the correct numbers relative to the question at hand".

Averages vs. Distribution (Variation) – there's a fundamental rule of nutrition and feeding that "you never know the true value of anything" (Weiss, 2004). There are reasonably accurate estimates of the nutrient requirements of production, with good accuracy of the <u>average</u> dry matter intake for groups of cows and for the <u>average</u> nutrient composition of the feeds being fed. However, there will always be biological and process (i.e. mixing and sampling feed) variation that will occur that can cause the actual ration to be different from what the "averages" are indicating. Does this mean that due to normal variation we should give up on monitoring nutrition and and feeding management? Of course not! However, variation and proper interpretation of data must be understood and addressed. A common misinterpretation and handling of variation occurs with feed samples being over-interpreted. Weiss (2004) does an excellent job of discussing how to understand and manage feed ingredient variation.

Many areas of management including feeding should be thought of in terms of the probability of an outcome rather than an absolute number. In other words, how confident are you that the number you are working with actually represents the true situation? Looked at another way, knowing the distribution of data around an average allows the distribution to be used to determine how much confidence you should have when using an average value. The more variation, the greater the distribution, the less confidence that the average might truly represent the current situation.

Variation, or ***lack of consistency***, is a dimension of risk and gives good reason for monitoring (Fetrow, 2001). There inherently always will be some variation in outcomes on a dairy when we are dealing with biological units...or cows! Making milk is a manufacturing process, and in any manufacturing process there will be some degree of variability when inputs are put through a process. Cows fed the same ration will differ in their milk production; with an individual cow varying in production from day-to-day. Variation makes operating a dairy more difficult and less profitable because the outcome of a process (e.g. mixing feed) is not precisely known.

The unpredictability of a process (caused by variation) makes troubleshooting and planning of future outcomes more difficult. For example, either not having any mixing or feed intake records, or having records with a tremendous amount of day-to-day variation makes the monitoring of the impact of the nutrition program on cow health and production difficult. Variation in the predicted feed intake or other nutritional parameters can be thought of as deviation from the target points or goals, which obviously impacts the outcome. Without a monitoring system, variation cannot practically be measured or managed.

The best-managed, and typically most profitable dairies, seek ways to reduce variation and to better understand what is "normal variation and patterns" in daily processes (Reneau, 2007). Dairies that can create consistency through better processes will improve their ability to plan and improve management. Daily monitoring of several aspects of the milking, feeding, fresh cows, sick cows, and cow performance will allow quicker adjustments to be made as needed.

Meeting Specifications vs. Risk Management – It's unrealistic to say that with a biological manufacturing system (a dairy) that we're going to consistently meet exact specifications like might be considered in the manufacture of a car, textile, or other similar object. Rather, a preferred method of monitoring on a dairy is to collect data and interpret data that will allow a better probability of predicting a positive outcome, and allow doing this on a more frequent basis. Through the use of daily monitoring we want to increase the number of times and probability of making good decisions through the use of good data, and minimize the number of errant or bad decisions. Completely eliminating the bad decisions and unpredictable events due to the biological nature of the dairy industry isn't possible, regardless of the level of monitoring implemented. We aren't trying to meet exact specifications as are other industries, rather trying to maximize the probability of making good decisions through the use of monitoring.

Accuracy vs. Precision – How close to the target goals should a manager expect performance to be in feeding, fresh cow performance, milk production, milk quality, and other measurable parameters. When working with a biological system it's important that performance be evaluated in the context of being "accurate" relative to the target goals, versus trying to be "precise" or exact. Lets use an actual "bullseye target" analogy, with circles that constrict towards center and hitting the bullseye being the indicator of greatest precision. Accuracy can best be represented as consistently hitting within or near the bullseye, with no stray hits outside the inner-most circle. Precision on the other-hand could be represented as time and time again hitting the exact same spot on the target. Expecting to hit dairy performance targets with precision simply isn't realistic. Rather the

focus when monitoring should be to have excellent accuracy, and not be concerned that data does not repeat with precision.

Too Much Data vs. Relevant Data – too much aggregated data, from too many animals, summed over too many pens will tend to limit the value and relevancy of the information. The net result is the question at hand might not be correctly answered. An example of this might be knowing average dry matter intake for a herd, rather than knowing the dry matter intake for a specific pen. If looking at herd feed intakes, rather than pen intakes, because the denominator includes fresh cows, 1st calf heifers, possibly sick cows, and cows of all stages of lactation and production, the data is too broad and really doesn't tell you anything about feed intake and energy balance for the cows in early lactation. With any data, it's critical that both the numerator and denominator be known and appropriate for the question being asked.

Two Dots Don't Make a Line – the opposite of too much data is not having enough data, yet falling into the interpretation trap of over-analyzing limited data implying that it actually means something. Simply stated, it takes at least three data points to create any resemblance of a line with specific direction. If there are only two data points, the information could be completely misleading to the true direction. An example of this might be having two days of low milk fat test … does this really mean there is a pattern or an issue with fat test? Maybe or maybe not. However, if there are 3-4 days in a row with low fat test, this very likely is a data line that is likely pointing in a direction that warrants investigation and/or intervention.

Benchmarking vs. Monitoring – benchmarking is a very common practice used across industries, including the dairy industry comparing peer results to performance at a given location. Benchmarking is always of interest because it looks at the "competition" and helps assess where a business stands relative to its peers. This will always be an important aspect of business analysis. However, there is big watch out with using benchmarking to monitor performance on a dairy.

The only time that benchmarking should really be used to make specific management decisions and changes is when clearly the benchmarks being compared have been calculated with the same exact definition for the numerator and denominator. A simple example might be comparing the retained placenta (RP) rate between three different dairies, where the dairies all use a different time period and/or method to define what actually constitutes a RP. Dairy A might only have a RP incidence rate of 6%, while Dairy B has a RP incidence rate of 9%. Knowing this information may not accurately indicate which dairy actually has the better fresh cow program. Clearly, this might have very limited value on a given dairy, versus daily monitoring of fresh cow performance , and taking timely and appropriate action for each and every RP that does occur.

Monitoring vs. On-farm Experiments – there is a common fallacy that if a dairy runs a feeding trial or experiment on their farm that the collected data and information will provide better insight to whether the practice being tested should be implemented. The fallacy of this is that relatively imprecise data measurements (always the case on individual data gathered on-farm due to all the biological normal variation) when added to a set of relatively precise (controlled research data) will actually improve the accuracy of the overall data set. This is simply false!

This is not to imply that on-farm monitoring of new practices and changes shouldn't occur…of course they should be. However, monitoring should be focused on determining if the implementation of the technology or change is a good fit for the dairy, and whether by adopting the technology is there a trend and pattern towards a more improved cash flow and long-term profit. When trying to answer whether the biology and science is sound behind an adopted technology or management change, only controlled research should be used to answer the "why and how does it biologically work" questions. Use on-farm monitoring to answer the "does it fit" and "does it appear to be improving cash flow and long-term profitability" questions.

Normal vs. Abnormal Variation – there will always be variation around an outcome; the key is to establish what is considered "normal" variation and monitor for the outliers or data that signals there is something abnormal going on. An example of this might be the normal daily variation that will be seen in fat test when taken daily on multiple loads of milk from the same dairy. We probably shouldn't concern ourselves with a fat test bouncing around from 3.4% to 3.6% between daily loads due to normal variation associated with the pens milked and sampled, time of day of milking, and analytical variation with testing milk fat. However, if a pattern over multiple days of average daily milk fat tests had been consistently running from 3.50 to 3.55%, and suddenly the daily average drops to 3.40 for three consecutive days this clearly would be a signal that something needs attention. The key is knowing the variation pattern and watching for "outliers" to the pattern. There will always be biological variation, and the pattern of this normal biological variation must be established. This can only be done with daily monitoring and collection of good data.

With good data, upper and lower limits can be set when data falls outside normal variation. These outliers are often referred to outliers, signals or "flags" that intervention may be needed. An example might be the number of days that animals spend in a close-up group prior to calving. With proper monitoring we can focus on average days in the pen, distribution of the average number of days in pen, and most importantly the metabolic incidence rates associated with the animals that fall outside the targeted upper and lower limits (i.e. 18-24 days target distribution with the average days in pen target being 21 days). Days in the pen will vary, looking at abnormal variation is the key!

The average, or central tendency of the data, likely is not the only acceptable outcome, but rather "acceptable" is a range within normal variation from the average. Often if three data points are near the upper or lower limits, this might be considered a signal that further investigation or intervention is needed. Usually, intervention based on a single outlier must be carefully considered when working in a biological system. Here's a key point - remember that "abnormal variation or data" might actually be a good indicator, such as a cow being in heat thus her walking pedometer activity for a given day is very high and becomes manageable outlier data.

Statistical Process Control - there currently is a lot of discussion of how to apply well proven Statistical Process Control (SPC) principles on-farm to allow better monitoring and interpretation of farm generated data. Reneau, 2007 has written a detailed chapter discussing the principles, value and implementation of using SPC to improve herd performance. Statistical Process Control is a method of interpreting time-series data using a statistical process, which has been widely adopted across other industries and is

commonly used in the poultry and swine business. The general principle of SPC is having ample good data collected on a regular basis that generates a historical perspective and "normal" pattern to the data. Statistical process control then is looking for irregular data patterns or "outlier data" that might be interpreted as a management issue that may need addressing. The underlying concept behind using SPC is to create more reliable processes and outcomes, with the intent being the ability to generate consistent results under all circumstances. Herein lays the potential blind spot of the dairy industry trying to fully embrace SPC type management on dairies. Let's remember, we are dealing with a biological manufacturing system (cows, people, and weather).

The tradeoff of aggressively striving for more reliable systems when dealing with a biological based business is that these same systems may become less "accurate or valid" to what is trying to be accomplished. Lets explain. Just because a process is very reliable, or repeatable over and over, doesn't mean it is necessarily meaningful or accurate. The saying goes, "are you doing things right, or are you doing the right things". Adding "gut feel" and utilizing the craft and skills of employees to interpret the often-changing cows and feeds may actually deliver more "accurate" results when done in combination with data collection and monitoring. Think of this as "reliability versus accuracy".

Yes, dairies will benefit from more reliable processes such as feeding where the results are more consistent (ration crude protein varies very little from day-to-day). But what if the cows are suggesting based on observational factors that the accuracy of the ration relative to rumen function, milk production, and manure consistency isn't very accurate (simply put "not getting the job done") then what good is having very reliable results? Accuracy and reliable are a constant "push-pull" concept in data management. Producing accurate and repeatable results on a dairy requires that both qualitative as well as quantitative data be utilized, and dairies would be wise to think this through before implementing a SPC monitoring system. A good example of this might be fresh cow monitoring, and how utilizing temperature monitoring (quantitative) along with visual appraisal for "attitude and appetite" (qualitative) might be the best system. Standard process control systems typically address only the quantitative side of the picture.

Problems with Parameters

No parameter is perfect, although some are better than others. Parameter problems can be categorized as follows (Eicker et al., 2002; Fetrow et al., 1997):

1. Variation
2. Momentum
3. Lag
4. Bias

Variation results from one number having a large impact on the result. Data analysis for small herds is often limited for this reason. For example, suppose in one week that a group of 10 cows were palpated for pregnancy, and 4 were checked pregnant. Suppose the next week that another 10 cows were palpated, and 3 were pregnant. The numbers would suggest that palpation pregnancy rate dropped from 40 to 30%. This is a 25% reduction in palpation pregnancy rate. Did the dairy really get 25% worse?

Momentum is when too much time goes into the calculation, making changes difficult to detect. Large changes in performance are not detected quickly if there is too much momentum. Rolling herd average, days open, calving interval, and average milk peaks are examples of parameters with too much momentum. Rolling herd average is the classic example of a number that is very slow to change, since a years worth of data goes into the calculation.

Lag is the time between when an event occurs and when it is measured. Age at first calving is a parameter that has significant lag. By measuring age at first calving, we are measuring an event that happened 9 months ago (conception). Although a heifer grower may want to record age at first calving for a report card or for marketing purposes, it has no value as a monitor.

Bias occurs when data is ignored or not included in the calculation. This includes using a subset of the herd, or not accurately recording data. Conception rate is a good example of a parameter with bias. Suppose a dairy has 100 cows come into heat in a give 21 day period. The dairy feels confident that 50 of the cows are in good heat and will conceive, but not sure of the other 50. If only 50 are bred, and 30 conceive, the records would indicate an 60% conception rate (30/50). If all 100 cows were bred, and 40 conceived, then conception rate is 40%. If conception rate were the parameter used to monitor success, the first alternative would be optimal. However, the latter example with a lower conception rate resulted in 10 more pregnancies!

What Should be Monitored?

Traditional monitors include rolling herd average, milk peaks, days open, calving interval, age at first calving, etc. Previous discussion tells us that these parameters are worthwhile as report cards, but of limited use as a monitor due to time lag and other limitations to the data used in the parameter. The biggest issue with these often used measures of performance is they are historical by nature and if these parameters get worse, the dairy has likely had a problem for some time. Too much lag! Monitor parameters that will quickly tell us when a management intervention is warranted.

Let's begin by asking "what questions should we be asking daily on a dairy"? Here are some questions and thoughts pertaining to each question:

1. Number of fresh cows and metabolic events?
2. How many sick cows are there today and number of new mastitis cows?
3. How many DOA calves and live calves are there? Number of heifers born?
4. Are cows getting pregnant?
5. What are culling reasons and patterns telling us? Number of dead cows?
6. Lame cows identified?
7. By pen, are feed intakes meeting targets and how much variation is occurring?
8. Daily milk production and number of cows milked today? How many cows in each pen?
9. How did each milking shift perform? Milk pounds per stall/hr? Start/finish times?
10. How are the "good" cows performing?
11. How many "bad" cows are there and what cows are on "down 20 lb list" for milk today?

12. How are first lactation heifers doing compared to older cows?
13. What are milk fat, milk protein, SCC, and MUN for recently shipped milk?

Are my fresh cows doing well? Monitors of limited value include average milk peaks in the herd, or any other "average" that applies to cows that calved over different time periods. Better monitors include calving disorders as a percent of calvings, milk weights during specific time periods during the first 60 days fresh (requires daily milk weights), first test milk weights from last test day, and 30 and 60 day cull rate (number of cows left less than 30 and 60 DIM divided by calvings).

Metabolic disorders should be tracked as a percent of calvings. It is useful to compare first lactation disorders separately from older cows. Dairies do not all record metabolic disorders in a similar manner, so they are difficult to compare or benchmark. For example, what is the definition of an RP? Is it a retained fetal membrane soon after calving, 24 hours after calving, 48 hours after calving, or only when a cow goes to the hospital? Incidence of DA is more straightforward. Milk fever incidence can be impacted by the aggressiveness of the herdsman in the fresh pen. Ketosis is very subjective and difficult to benchmark. Having said this, some reasonable goals are less than 3-4% DA's, less than 9% RP's, and less than 1-1.5% milk fever. Season and environment will obviously impact these numbers.

Percent born dead (DOA's) for cows and heifers calving is a useful monitor of calving problems and the work being done in the maternity area. Live and dead calves should be known daily, with number of fresh cows recorded daily. Cows in the sick pen directly reflects profitability and should be monitored. Sick pen cows should average less than 2% of the herd milking, with new mastitis cases recorded daily.

Are cows getting pregnant? Monitors including days open and calving interval are of limited value. In asking "are cows getting pregnant", we are most concerned with the open eligible cows in the herd, and the rate at which they are conceiving. The most appropriate monitor is 21 day pregnancy rate, which is the number of pregnant cows every 21 days divided by the pregnant eligible pool (cows beyond the voluntary waiting period that are not DNB's). The rate at which cows are resynchronized is also important. The percent of cows herd checked pregnant as percent of all eligible cows checked is important to every dairy producer, with the total percent of the herd pregnant being an indicator of "hard count" pregnancies needed to maintain herd size without purchasing animals.

What are culling patterns telling us? Annual cull rate is a poor monitor to answer this question. Three additional questions further refine the issue: are too many fresh cows leaving and why, why are cows leaving based on remarks and reasons, and are the cows that need to be culled leaving? Calculating a 30 day (or 60 day or 90 day) culling rate, as previously described, will answer the first question. Looking at all cows that have left the herd very recently with remarks and events noted will provide reasons of why cows left the herd. Quantifying the number of "bad" cows or "DNB" cows will address the second

question. Any cow that is open, >100 DIM, and less than 35 lbs of milk is likely a "bad" cow when other animals are available to trade-up and fill an available stall.

Are the "good" cows performing? Which are the "good" cows? Recent milk peaks, or production for cows in the earlier stages of lactation should be monitored to evaluate how the "good" cows are milking. The percent of cows over 100 pounds of milk may be meaningful, along with the "ceiling level" of milk production, or the top level that cows are achieving under current feeding and management conditions. A goal is at least 20% of the herd should be milking over 100 lbs per day, with excellent herds typically being over 40% of the herd. Milk production should always be monitored by pen and for 1st lactation and older cows.

How many "bad" cows are there? Every dairy should have its own definition of a "bad" or unprofitable cow. Once the criteria for a "bad" cow are established, is the dairy removing these cows from the herd, or are they holding on to them? For most dairies, cows that are >100 DIM, open, and <35 lbs would be a "bad" cow. Criteria for a cow to become a DNB should be clearly defined by the management team.

How are my first lactation heifers doing compared to older cows? Mature equivalent (ME) production is an attempt to correct milk production for age, among other factors. Comparing 305ME for heifers and cows provides a report card for how heifers have done. First or second test 305ME projections provide more timely data and provide a sense of direction of how fresh cows are doing relative to previous points in time. Both reproduction and health data should always be evaluated based on lactation number, specifically looking at differences in 1st lactation heifers relative to cows.

How are feed intake levels and variation by pen? Knowing pen dry matter intake and the previous 7 day pattern and variation around the average intake is very valuable. The key is knowing daily pen counts, TMR moisture, feed dropped by pen, weighback amounts and moisture. Typically, higher intakes will result in better milk production and energy balance of the cows. However, feed efficiency may actually suffer with higher intakes indicating one of the values of knowing intake along with milk production by pen (Linn, 2004). Possibly more important than knowing the average dry matter intake by pen might be knowing the amount of variation in intake within a pen. Dry matter intake will vary from pen movements, weather, forage quality and numerous other factors. Consider that feed intake is not static even when these variables are relatively constant, and the "normal variation" must be established as the criteria in which the monitor is being measured against. Cows may not truly regulate feed intake in 24 hr patterns, so imposing our human "24 hr day" system of evaluating a cow's dry matter intake pattern may not be all telling. It might be more telling to evaluate intake patterns in slightly longer intervals such as 48 hrs to assess normal versus abnormal variation.

What is the pattern of milk fat, protein, and other components? Milk fat might be considered a "standard" in the industry for monitoring nutrition and feeding. Although valuable, it's documented that fat test is often misinterpreted and over-interpreted in terms of evaluating the true status of rumen health and energy status of cows, and would

best be carefully interpreted. The ease of milk fat data collection clearly suggests it should be used as a monitor on all dairies, but with careful interpretation and understanding of normal random variation versus abnormal variation within a given dairy. Milk protein and milk urea nitrogen are valuable monitors and have been well discussed in many other papers.

Cow Evaluation – Measurable?

Considerable time is spent in the industry walking pens and evaluating what we see, smell, feel, and hear. In part we want to determine if the cows are healthy and productive, and to find problems that may exist with the cows. Each person has specific things they like to see when walking pens, along with subjective measures of rumen and cow health. Probably the most subjective of monitors recommended, these parameters and monitors combined with experience are invaluable in performance monitoring if a tracking system can be established.

Cud Chewing - this may be one of the most overrated monitors used in the industry because of the subjective nature, yet can be a very valuable monitor. Many advisors to dairy producers promote the importance of monitoring cud-chewing as an indicator of normal rumen function. The limits of using cud chewing as a monitor comes from the subjective nature of how it's measured and the limited accuracy of the "data". Cud chewing can vary tremendously throughout the day in relation to time of feeding, milking, lockup, and other activities that may interrupt the cow's routine. Is "more" cud chewing always a good thing? One way to really get cows chewing more is to force them to consume some really low quality forage!

Just because a predetermined percentage of a group is not chewing their cud during a single walk-through, does this mean they are not healthy or productive? A good approach to consistently monitor cud chewing is to choose a spot and time to monitor, and compare over multiple days. Another way to improve the accuracy of the data is to make an assessment of cud chewing on the entire herd even though multiple pens may be involved. The milking parlor is an under-utilized place to monitor cud chewing – consider the location standardized across pens and all animals. In the parlor, within a few minutes of the machine being attached, cows should be relaxed and likely to chew. In the author's experience, consistently high performing herds will achieve in excess of 50-60% of the cows in the parlor chewing at any given time post machine attachment. This figure often will approach 90% of the cows on a given side of the parlor, including during periods of heat stress if ample cow cooling is being provided.

Manure – this subject has been a popular topic in recent years, and a thorough discussion could fill an entire paper (Hall, 2003). Although a very subjective monitor, most consider manure evaluation important, looking for consistent manure within a pen, and little variation across the herd. Normal variation within pen might be considered as 2-3% "too loose" and 2-3% "too stiff", although every nutritionist and veterinarian has a different definition of "loose" and "stiff". Loose manure can result from protein imbalances, irregular feeding patterns, forage moisture swings, acidosis, moldy and/or mycotoxin contaminated feeds, and sorting among other items. Loose manure with

bubbles, off-color, greasy appearance, or strong smell is a cause for concern and further investigation. It is not unusual for "just fresh" pens to have a higher percentage of loose animals. Presence of mucus or small amounts undigested feed in the manure is disconcerting to many nutritionists, but in practicality it's not always a cause for intervention. Some ingredients such as whole fuzzy cottonseed or cracked soybeans will almost always have 1-3% of the seeds (by weight fed) pass into the manure undigested, yet these ingredients are staples in many successful dairies.

The key to manure monitoring is to realize we are looking for "outliers" more so than the average composition. Washing of manure is of limited value to the author given the highly subjective nature of interpretation (Stone, 2005). Compared to low producing herds, high producing herds often have more mucus and small amounts of "undigested" feed in the manure, typically from a higher feed intake and rate of passage.

Locomotion – the purpose of locomotion scoring is to evaluate foot health in a herd. Without formally scoring every cow, it is useful to watch cows walking to and from the milking parlor to evaluate foot health. Cows with a normal gait should place their rear foot in nearly the identical place the front foot just vacated. Cows should also walk and stand with a straight back. Quantifying foot problems is difficult in many situations, but overall as a monitor area, this has a lot of merit. Monitoring foot health and locomotion is very valuable and should include monitoring cows missing scheduled trims, interpretation of foot trimmer report, number of new lame cows, and foot bath management.

Monitoring Mixing, Feed Delivery, and Bunk Management

The process of taking feeds from storage, accurately weighing and mixing the feed, and then delivering the proper ration to the correct pen of cows seems rather straight forward. That is until we consider the moisture variations that can occur in forages (Stone, 2005) and other feeds stored outside, the changes that can occur regularly with forage quality, the difficulty in accurately weighing some ingredients, ease in which feeds can either be over or under-mixed, and the human errors that can occur throughout the feeding process for various reasons.

A high plane of nutrition consumed on a consistent basis has a tremendous impact on the overall success of a dairy. A key component of nutrition is obviously feeding and bunk management. Given the high variable costs associated with feeding and the impact nutrition has on herd performance and health, it becomes obvious that establishing a daily nutrition and feeding monitoring program is very financially beneficial.

Monitoring of the feeding program can be broken into two distinct areas, the first being the parameters that the feeder and nutritionist closely monitor, and the second area being parameters that the owner/manager and nutritionist typically monitor. Although there certainly will be overlap between these, it has been helpful to establish specific responsibilities with many of the monitors better suited for the person actually doing the daily feeding.

Parameters Monitored by Feeder

Mixing feed, delivery of feed, and bunk management can be quite comprehensive, including all aspects of determining the batch size, frequency of feeding, timing of feeding, feed delivery to the bunk, feed push-ups, feed stability and bunk-life, actual intake and recordkeeping, feed sorting, feed weigh-back management, and the bunk environment including stocking density and manger design.

One of the greatest areas of feed variation that requires monitoring is with forages whether ensiled or dry hay are being fed (Stone, 2004). There are several parameters of forage and feed quality, along with TMR bunk management, where a feeder and nutritionist should work together to establish a monitoring system of these parameters that uses both a subjective and quantitative analysis, including:

- Moisture content of forages, other wet feeds, and the blended TMR .
- Smell and fermentation quality of ensiled feeds before feeding.
- Excessive wet or otherwise bad forage that needs to be isolated or discarded before mixing.
- Identifying feeds which are heating prior to coming out of storage.
- Particle length of forages from storage, after mixing, and in the bunk.
- Proper kernel processing of corn silage and grain particle size.
- Baled hay coarseness, stem texture, and mixing properties of the baled hay.
- Ingredient inventories adequate to complete the next day feedings.
- Proper appearance of blended protein or grain mixes based on the actual formulation.
- Occurrence of moldy feeds that need to be discarded.
- Level of weighbacks in each pen requiring removal before feeding.
- Accurate cow pen counts to determine batch sizes needed.
- Level of sorting assessed by comparing the fresh TMR relative to the weighbacks.
- Heating and secondary fermentation of the TMR that may occur in the bunk.
- Frequency of TMR pushup and adequacy of having TMR available the full length of the bunk at all times.

Have nutritionists truly invested in training the proper people that have a key role in the feeding management? Something as key, and relatively straight forward, as moisture determination has several breakdowns due to lack of understanding and clarity on the behalf of many feeders. This lack of understanding still exists on many dairies as we speak. Moisture monitoring is an excellent example of how for key performance monitoring to be successful, there must be all three key components of 1) protocol, 2) proper training, and daily habit-forming data collection that includes organizing and interpreting the data.

A big advantage of implementing a feeding monitoring program is the ability to better manage the consistency of the day-to-day rations being delivered. The key to improving mixing accuracy, feed inventory control and reducing shrink and variation is setting up a well-understood and effective monitoring system for measuring feed disappearance charged against inventory. Examples can be cited of dairies that experienced a significant health challenge with fresh cows, or a dairy that lost a large amount of milk production because of errors that were being made in the mixing or feeding program, yet essentially no records were available to quickly and accurately determine specific causes or to allow implementation of a better management plan.

There are several methods to monitoring and tracking the actual loading, mixing and feeding process. No one system will fit all dairies, nor are any systems 100% accurate. Essentially, there are three ways to approach setting up a monitoring system, including: 1) using a simple "pencil & paper" system of recording with preprinted forms, 2) using a combination of #1 and spreadsheets, or 3) using a computerized software program specifically developed for tracking and monitoring feeding and inventories that integrates with the scale on the mixer, in combination with #1 and/or #2. Each of the systems has its advantages, with clearly the future being with radio frequency scale integrated feed management programs that allows real time data collection of the actual feeding.

Feeding Parameters Monitored by Management

Are my feed costs acceptable? Feed cost per cow per day is often used as the primary monitor of feed costs, but is limited as a monitor for obvious reasons given that higher producing cows eat more feed. Feed cost per hundred weight of milk is a better measure of feeding economy, and has some use as a report card but limited use as a monitor. Income over feed costs (IOFC) is a better monitor for short term decisions. As an example, consider two herds with varying production and feed costs, but similar milk price ($15/cwt). Herd A has low feed costs ($2.95/d) and low milk production (65 lbs/d), while Herd B has higher feed costs ($3.40/d) and milk production (75 lbs/d). Feed cost per hundredweight is $4.54 for Herd A and $4.53 for Herd B. However, Income over Feed Cost (IOFC) is $6.85 for Herd A and $7.85 for Herd B. Which is more profitable?

This example illustrates several points. First, feed cost per hundredweight is not necessarily a good monitor. Second, benchmarking between herds can be very misleading. Feed cost per hundredweight is not adjusted for fat and protein content of milk, so herds with higher components will often have a higher feed cost per hundredweight, all else being equal. Some dairies will also include dry cow feed cost in the feed cost per hundred weight calculation, while other dairies will not. This can be a significant source of error when benchmarking feed costs between dairies. Generally, using both IOFC and Feed Cost/Cwt of milk will provide a more accurate assessment of feed costs than either one alone, and certainly both of these monitors are better than feed cost per cow/day.

Since protein and commodities typically represent a large majority of purchased feed costs, closely monitoring and managing these costs can represent very large contributions to the year-end bottom-line. Without ever compromising quality, risk management

strategies should be utilized and monitored as part of feed cost management that includes bids, contracting, and other price protection vehicles where appropriate. Cost of inventory and shrink are often under-estimated when considering the types of ingredients and storage that best fit a given dairy. Regular monitoring of purchased feed costs should be implemented at every dairy.

There are other feed cost related questions to ask, depending on the goals and structure of the dairy. Many nutritionists want to know if cows are efficiently converting feed to milk. The milk:feed ratio (pounds of milk per pound of dry matter intake) is typically monitored to answer this question. This number does have some value as long as the context of how it's interpreted is understood. Feed efficiency will vary considerably (Hutjens, 2005, Linn, 2004) depending on numerous factors, including herd make-up (portion of herd that is heifers, days in milk for the herd), and accuracy of measuring true intakes versus feed delivered, and actual shipped milk by pen.

Summary

The economic incentives for establishing daily key performance monitoring are large (Fuhrmann, 2007). Often, when data is available it's under-utilized or almost equally as bad - misinterpreted. Develop an organized, yet simple, monitoring program that collects data daily on key parameters that have the greatest impact on the financial success of the dairy. Monitoring should be agreed upon and embraced by the managers at the dairy, nutritionist, veterinarian, ag lender or accountant, and management team alike.

Recognize the significant costs and risk associated with variation, and yet the power and value of better understanding variation associated with different processes on a dairy. Remember, variation is normal while the outliers are what signal change may be needed. Focus on the areas which contribute to the greatest variation. Organizing data to simplify regular review and interpretation is very valuable. Use of posted graphs and colored reports are effective. Recognize the errors that can be made in data interpretation, while focusing on outlier data and variation from target rather than averages. Consider implementing Statistical Process Control management into dairies you support.

Prioritize written protocols and the training and retraining of the proper people based on what monitors are telling the management team. Training and protocol development is a key area of service that can be provided by veterinarians and nutritionists. Help set clear expectations with the entire dairy management team as to what the goals and commitments are for improving the performance of the dairy through the use of key performance monitoring. Build sound protocols using solid science, train and retrain the proper employees, and monitor the work of employees and cow performance.

And don't forget to celebrate the success and improvements along the way!

References:

Barmore, J.A., 2002. Fine-tuning the ration mixing and feeding of high producing herds. *Proceedings* Tri-State Nutrition Conference, Fort Wayne, IN. pp.103-126.

Barmore, J.A., 2001. Monitoring & Managing Feeding, Inventory, & Shrink. *Proceedings* Four-State Applied Nutrition and Management Conference. LaCrosse, WI. Pp. 75-86.

Bethard, G. and S. Stokes. On-farm Tools for Monitoring Feeding & Production. *Proceedings* Western Dairy Management Conference. April 8-10, 1999. Las Vegas, NV. Pg. 114-123.

Deming WE. Out of the crisis. London: The MIT Press; 1986.

Eicker, S., S. Stewart, J. Fetrow, P. Rapnicki. 2002. Monitoring Transition Cow Programs. S.A.T.A. Technical Meeting. December 2-6, 2002. Milan, Italy.

Fetrow, J. 2001. Making Dairy Management Decisions in a Financial Context: Moving Beyond "Common sense" in Dairy Decision-making. *Proceedings* Minnesota Dairy Herd Health Pre-Conference Seminar. May 22, 2001.

Fetrow, J., S. Stewart, S. Eicker., 1997. Reproductive Health Programs for Dairy Herds: Analysis of Records for Assessment of Reproductive Performance. in Youngquist, Current Therapy in Large Animal Theriogenology, pp 441-45.

Fuhrmann, T. 2007. Persoanl Communication at DairyWorks Workshop. Phoenix, AZ.

Hall, M.B. 2003. Feeding and Reading Your Cows: Carbohydrates and Manure in Ration Management. *Proceedings* Tri-State Northwest Dairy Shortcourse.pp.9-16.

Hutjens, M.F., 2005. Dairy Efficiency and Dry Matter Intake. *Proceedings* Western Dairy Management Conference, Reno, NV. Pp.71-76.

Linn, J., 2004. Feed Efficiency of Lactating Cows. *Proceedings* 65th Minnesota Nutrition Conference, St Paul, MN. Pp.38-46.

Natzke, D., 2005. Profitability is a Process. Midwest Dairy Business. January 2005. pp.11-18.

Reneau, J.K. and J. M. Lukas. Using Statistical Process Control to Improve Herd Performance. 2006 Veterinary Clinics of North America: Food Animal Edition. WD Sanders.

Stewart, S, J. Fetrow, S. Eicker., 1995. Field Use of DHIA Somatic Cell Counts with Scatter Graphs, Compendium of Continuing Education, 17:11 1429-1439.

Stone, W.C., 2005. What is Acceptable Variation in the Nutrition Program and How Can It Be Managed?. *Proceedings* Southwest Nutrition & Management Conference, Tempe, AZ. Pp. 1-10.

Stone, W.C., 2004. What's this? Minimizing the Variation Between Formulated and Consumed rations. *Proceedings* Southwest Nutrition & Management Conference, Tempe, AZ. Pp.107-113.

Weiss, W.P., 2004. Randomness Rules: Living with Variation in the Nutrient Composition of Concentrate Feeds. *Proceedings* Mid-South Ruminant Nutrition Conference, Arlington, TX. pp.39-46.

Weiss, W.P., 2004. Fine-tuning Energy Calculations. *Proceedings* Tri-State Nutrition Conference, Fort Wayne, IN. pp.131-142.

Wheeler, D.J., 2000. Understanding Variation – The Key to Managing Chaos. SPC Press.