ECONOMIC ANALYSIS OF DIAGNOSTIC PROCEDURES COMMONLY USED IN BOVINE THERIOGENOLOGY

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INTRODUCTION

Veterinary practitioners are involved in helping food animal clients meet a number of specific reproductive goals. These include having a high percentage of females exposed to bulls becoming pregnant (i.e. enhance fertility or minimize infertility), minimizing the effects of infectious, metabolic, and other disease processes that can cause pregnancy loss, and enhancing the genetic value of the herd through selection and multiplication of economically superior parent animals. To aid their evaluation of an operation's reproductive efficiency, practitioners have a number of tests available to them for use in screening, monitoring, and diagnosing populations and individuals. Commonly utilized diagnostic procedures include:

- Breeding soundness examination of bulls (BSEB)
- Breeding soundness examination of heifers
- Body condition scoring
- Pregnancy diagnosis via uterine palpation or ultrasonic examination per rectum
- Feed evaluation (nutritional and toxicological)
- Diagnostic laboratory tests for infectious disease agents (serology, immunohistochemistry, PCR, virus isolation, bacterial culture, etc.)

Many theriogenologists express frustration when trying to determine the economic value of these procedures. In an attempt to determine a value and hence, an appropriate fee to charge clients, some practitioners are tempted to use simple, but possibly inappropriate methods.

To determine the economic return for diagnostic testing strategies, veterinarians need information pertaining to: sensitivity and specificity of available diagnostic tests, prevalence of the condition in question in the population at large and specified sub-populations, disease dynamics such as reservoir, transmission pattern, incubation period, immune response and pathogenicity (if diagnosing an infectious disease), treatment efficacy, and negative or unintended consequences of diagnosis or treatment. In addition, food animal veterinarians must also have data on the economic cost of the condition and the economic cost of intervention.

The most appropriate method to determine the economic value for diagnostic testing will vary depending on the condition in question, the time frame involved, and how the diagnostic information will be utilized to make decisions. The most straightforward method is by utilizing a partial budget. For rare conditions or events, it may be more appropriate to determine the cost of a negative outcome and the cost of intervention and working with the client, determine his/her level of risk aversion, and together, determine the value of reducing the risk of a rare event. For disease conditions with an endemic or long-term effect, and for production enhancement or protection of breeding herds, multi-year enterprise or whole-farm assessment may be most appropriate. Some aspects of diagnostic testing may fall outside the ability of economic evaluations to determine a value because the benefit and risk are immeasurable.

DETERMINING DIAGNOSTIC TEST USEFULLNESS AND DIAGNOSTIC STRATEGY

A valid question confronting veterinary practitioners is whether to use available diagnostic tests to screen a particular herd for a particular condition. The input that one needs to arrive at a logical conclusion includes: epidemiologic data about the condition or disease, diagnostic test sensitivity and specificity data, disease or condition dynamics, and economic costs of the condition and its treatment. Literature review and mathematic aids such as computer spreadsheets and expert systems are the tools used to create the necessary outputs. These outputs include post-test predictive values of diagnostic tests, economic value of testing, sensitivity of the decision to the individual inputs, and the importance of individual inputs to the decision. These outputs are used to evaluate alternate diagnostic testing strategies in order to indicate the best testing strategy, and to identify the control points that will be monitored for change that can trigger a re-evaluation of the decision.

Sensitivity and Specificity of Diagnostic Tests

Sensitivity and specificity are properties of a diagnostic test that are determined by comparing the test to a “gold standard”. The gold standard is considered the true diagnosis and may be made using a variety of information such as clinical examination, expert opinion, laboratory results, or postmortem results. Sensitivity is the proportion of known positive (gold standard-positive) samples that the test in question identifies as positive. Specificity is the proportion of known negative samples that the test in question identifies as negative. In other words, sensitivity answers the question, “How effective is the test at identifying animals with the condition?” and specificity answers the question, “How effective is the test at identifying animals without the condition?” Because diagnostic tests (both laboratory and clinical examination tests) use an arbitrary cut-off to separate test-positive and test-negative populations, sensitivity and specificity are inversely related, and placing the cut-off is always a trade-off between the impacts of false negative and false positive results.

Prevalence

Prevalence is the ratio of the number of cases of a particular condition at a given time to the size of the population at that time. The known or suspected prevalence is the *a priori* probability of the condition being present. Unfortunately, there is limited published, timely prevalence information for most of the infectious diseases and reproductive conditions (infertility, subfertility, non-pregnant, etc.) of interest to veterinary medicine. Each practitioner’s judgment, based on history and clinical examination of both individuals and the population, aided by what prevalence information is available, is often all that is available to establish the *a priori* probability for both infectious diseases and reproductive conditions. A well-studied aspect of Bayesian inference is that, for a test with imperfect specificity, an increasing proportion of the test positives will be false positives as prevalence decreases. At low prevalences, the majority of test positives will be false positives, so that for an uncommon condition, even a highly accurate test will render inaccurate results when applied to the animal population as a whole.

Post-test Predictive Value

The post-test predictive values of a test are determined, not in the laboratory, but in the field and they tell a diagnostician if a valid test is useful. The positive predictive value is the proportion of animals with a positive test result that are actually positive and is influenced by test specificity. The negative predictive value is the proportion of animals with a negative test result that are truly negative and is influenced by test sensitivity. Both the positive and negative predictive values of a test are affected by the prevalence of the condition. As the prevalence of the condition is raised, we have more animals with the condition in the population, and we have greater confidence that a positive test result is correct. With increasing prevalence, the positive predictive value of the test is increased and the negative predictive value is decreased, while the reverse is true as the prevalence of the condition is decreasing.

The probability that an animal that tests positive is truly positive (positive predictive value or predictive value of a positive test) is computed as:

$$PV+ = (Se \times P)/[(Se \times P)+((1-P) \times (1-Sp))]$$

The probability that an animal that tests negative is truly negative (negative predictive value or predictive value of a negative test) is computed as:

$$PV- = (1-P)/[(1-P) + ((1-Se)/(Sp))]$$

Where Se is test sensitivity, P is prevalence, and Sp is test specificity.

It is often not possible to estimate prevalence with any confidence, but one must still consider predictive value in test interpretation. When screening a herd, one often has no *a priori* data to suggest that an individual animal is in a particularly high prevalence group. In such a mode, a negative test result has a high negative predictive value and is useful in striking a rule-out off the list, but a positive test result (which is most likely a false positive) is useful only in keeping a rule-out on the active list.

Diagnostic testing strategy

The interpretation of a test result is dependent on whether the test is assisting the decision to rule-out a preliminary diagnosis, rule-in a preliminary diagnosis, or as a form of ruling-in a preliminary diagnosis - to screen for regulatory or biosecurity reasons. This is true whether one is considering an infectious disease agent such as *Brucella* sp. or Bovine Viral Diarrhea Virus or a reproductive condition such as an open cow or subfertile bull. To rule-in a preliminary diagnosis, many times it is necessary to use more than one test, either in series or in parallel. Running tests in series, where a second test is submitted only after the first test returns a positive result, is used to confirm a positive test with a low positive predictive value (low specificity or low prevalence). A two-test series is interpreted as negative if either test results in a negative response. Running two or more tests in parallel, where two or more tests are submitted at the same time, is used to confirm a positive test with low negative predictive value (low sensitivity or high prevalence). Parallel tests are interpreted as positive if either test results in a positive response.

DETERMINING COST OF DISEASE

Biology and economics intersect when veterinarians determine the cost of a negative condition. A number of tools are available to approximate the cost of a negative condition (disease presence, suboptimal body condition, non-pregnant after bull exposure, subfertile bull, etc.), and the biologic characteristics of the condition determine the proper economic analysis. Partial budgets are appropriate for diseases that are horizontally transmitted and immunity or other responses (death, sterility, removal from population, etc.) confine the negative effect of the disease to a short period of time; or for conditions whose negative effects are confined to a short period of time (i.e. correction of low body condition score effect on subsequent time period's feed costs). Multi-year enterprise analyses are more appropriate to estimate the economic cost of diseases that are vertically transmitted, due to an environmental source, have a chronic production-losing component, or to estimate the cost of conditions that have an impact on costs in subsequent years (open cows, subfertile bulls, etc.).

Partial Budgets

Partial budgets assist in the evaluating diagnostic strategies by evaluating changes in resource use and evaluating the economic effect of making one adjustment in some portion of the business. The success of using partial budgets depends on their prediction accuracy, which depends on the accuracy of the information and estimates they contain. Partial budgeting is based on the principle that a change in the organization of a business will increase some costs and decrease others, and increase some returns while decreasing other returns. The net effect will be the sum of positive economic effects minus the sum of negative economic effects.

When evaluating diagnostic strategies, the veterinarian and producer should collect data about the alternatives of using or not using the diagnostic strategy, such as current costs of production, costs of capital, commodity prices, or other items pertinent to the particular decision alternatives. In addition, reasonable estimates of future prices and animal production values (weight, efficiency, carcass value, etc.) are needed. Production estimates can be obtained from several sources including published research, extension bulletins, and current farm production records. Agricultural economists, USDA statisticians, and futures markets provide information about the trend of prices, and national production estimates.

The partial budget is ready to be developed after all pertinent data is assembled. The seven components of a partial budget are (Figure 1):

1) Additional returns
2) Reduced costs
3) Additional costs
4) Reduced returns
5) Total for the additional returns plus reduced costs
6) Total for the additional costs plus reduced returns
7) The net difference of 5) and 6)

Additional returns are those that occur if the diagnostic strategy is implemented. Reduced costs are those that are not incurred as a result of the proposed strategy. Additional costs are those that are only incurred if the strategy is implemented. Reduced returns are those that are no longer received if the strategy is initiated compared to the current situation. The difference between positive and negative economic effects is an estimate of the net effect of implementing the proposed diagnostic strategy. A positive difference indicates the potential increase in net returns if the strategy is implemented. Conversely, a negative difference is an estimate of the reduction in net returns if the strategy is adopted. The extent of the positive or negative difference, given the producer's confidence in the numbers used, impacts the final decision made. Only the costs and returns that change by proceeding with the diagnostic strategy should be included in the partial budget. The unit used to analyze the change may be any size (i.e. one head or the entire herd). After the analysis is performed, the result should be multiplied as necessary to show the economic impact on the entire enterprise or business.

Figure 1: Partial Budget Template

Section 1

Additional returns if strategy is adopted	Amount of change
1	
2	
3	
4	
5	
Interest gained on increased revenue	
Sub-total additional returns	

Section 3

Additional cost if strategy is adopted	Amount of change
1	
2	
3	
4	
5	
Interest paid on increased costs	
Sub-total additional cost	

Section 2

Reduced costs if strategy is adopted	Amount of change
1	
2	
3	
4	
5	
Interest saved from lower input costs	
Sub-total reduced costs	

Section 4

Reduced returns if strategy is adopted	Amount of change
1	
2	
3	
4	
5	
Interest lost on reduced returns	
Sub-total reduced returns	

Summary

Section 5	Total change in Benefits (Section 1 + Section 2)	=
Section 6	Total change in Costs (Section 3 + Section 4)	=
Section 7	**Net change in Income (Change in Benefits – Change in Costs)**	

Multi-Year Enterprise Analysis

In contrast to diseases with a confined time period of negative effect, evaluation of diagnostic testing strategies that monitor diseases that can become endemic (BVDV, neosporosis, trichomoniasis, etc.) require multi-year models that generate annual cash flow, balance sheet and income statements to compare alternate testing strategies. Similarly, diagnostic testing that monitors production (i.e. pregnancy proportion and temporal distribution, body condition score effect on reproductive performance, BSEB effect on bull:female ratio) also requires multi-year models.

Figure 2. Cash flow statement from multi-year enterprise analysis

		Cash Flow Statement					
		Dec. 31	Dec. 31	Dec. 31	Dec. 31	Dec. 31	Dec. 31
Income	Year	2003	2004	2005	2006	2007	2008
Crop Sales		$0	$0	$0	$0	$0	$0
Market Livestock Sales		$0	$0	$0	$0	$0	$0
Government Payments		$0	$0	$0	$0	$0	$0
Other Cash business Income		$0	$0	$0	$0	$0	$0
Operating Loan Proceeds		$0	$0	$0	$0	$0	$0
Loan Proceeds (T.D.&C.L.)*		$0	$0	$0	$0	$0	$0
Capital Asset Sales (Including Lvstk)		$0	$0	$0	$0	$0	$0
Non-Business Inflows		$0	$0	$0	$0	$0	$0
Other Non-Business		$0	$0	$0	$0	$0	$0
Other Non-Business		$0	$0	$0	$0	$0	$0
Other Non-Business		$0	$0	$0	$0	$0	$0
Total Cash Inflows		$0	$0	$0	$0	$0	$0

** T.D. = Term Debt, C.L. = Capital Lease*

		Dec. 31	Dec. 31	Dec. 31	Dec. 31	Dec. 31	Dec. 31
Expenses		2003	2004	2005	2006	2007	2008
Operating Expenses	No Interest	$0	$0	$0	$0	$0	$0
Other Cash Business Expense		$0	$0	$0	$0	$0	$0
Cash Int. Exp. - T.D. & C.L.*		$0	$0	$0	$0	$0	$0
Cash Int. Exp. - Operating		$0	$0	$0	$0	$0	$0
Loan Prin. Payments - Term Debt		$0	$0	$0	$0	$0	$0
Loan Prin. Payments - Cap. Lease		$0	$0	$0	$0	$0	$0
Loan Prin. Payments - Operating		$0	$0	$0	$0	$0	$0
Capital Asset Purchases		$0	$0	$0	$0	$0	$0
Owner withdrawals		$0	$0	$0	$0	$0	$0
Cash Taxes Paid (Income & SS)		$0	$0	$0	$0	$0	$0
Other Cash Outflows (Not Expenses)		$0	$0	$0	$0	$0	$0
Total Cash Outflows		$0	$0	$0	$0	$0	$0
Calculated Surplus (+) or Deficit (-)		$0	$0	$0	$0	$0	$0
Reported Ending Cash Balance							
Cash Discrepancy		$0	$0	$0	$0	$0	$0

Figure 3. Balance Sheet from multi-year enterprise analysis

	Balance Sheet						
	Jan. 1	Dec. 31	Dec. 31	Dec. 31	Dec. 31	Dec. 31	Dec. 31
Assets	2003	2003	2004	2005	2006	2007	2008
Cash on Hand		$0	$0	$0	$0	$0	$0
Crops for Sale & Feed							
Market Livestock		$0	$0	$0	$0	$0	$0
Other Curr. Assets (Inc.)							
Cash Invt Growing Crops							
Sup.&Prepaid Exp.(Exp)							
Total Current Assets	$0	$0	$0	$0	$0	$0	$0
Non-Current Assets							
Mach. & Equipment							
Breeding Livestock		$0	$0	$0	$0	$0	$0
Real Estate							
Other Non-Current							
Total Business Assets	$0	$0	$0	$0	$0	$0	$0

	Jan. 1	Dec. 31	Dec. 31	Dec. 31	Dec. 31	Dec. 31	Dec. 31
	2003	2003	2004	2005	2006	2007	2008
Accounts Payable							
Accrued Interest							
Current Principle							
Other Current Liability							
Notes Payable							
CCC Loans							
Def. Tax on Current							
Operating Loan Carryover		$0	$0	$0	$0	$0	$0
Total Current Liab.	$0	$0	$0	$0	$0	$0	$0
Prin. on Term Debt							
Prin. on Capital Leases							
Other Non-Curnt Liab.							
Total Business Liab.	$0	$0	$0	$0	$0	$0	$0
Business Net Worth	$0	$0	$0	$0	$0	$0	$0

Figure 4. Accrual Adjusted Income Sheet from multi-year enterprise analysis

Accrual Adjusted Income Statement

		Dec. 31 2003	Dec. 31 2004	Dec. 31 2005	Dec. 31 2006	Dec. 31 2007	Dec. 31 2008
Cash Income		$0	$0	$0	$0	$0	$0
Non-Cash Income Adjustments		$0	$0	$0	$0	$0	$0
Non-Cash Revenue (Trans Brding Lvstk)							
Capital Gain/Loss on Breeding Lvstk							
Gross Revenue		$0	$0	$0	$0	$0	$0
Cash Expense (Excluding Interest)		$0	$0	$0	$0	$0	$0
Other Non-Cash Non-Interest Expense		$0	$0	$0	$0	$0	$0
Depreciation & Amortization Expense							
Total Operating Expense		$0	$0	$0	$0	$0	$0
Cash Int. Exp. - T.D. & C.L.		$0	$0	$0	$0	$0	$0
Cash Int. Exp. - Operating		$0	$0	$0	$0	$0	$0
Non-Cash Interest Expense		$0	$0	$0	$0	$0	$0
Total Expense		$0	$0	$0	$0	$0	$0
Net Business Income From Operations		$0	$0	$0	$0	$0	$0
Gain/loss - capital sales (Not Lvstk)	+/-						
Net Business Income		$0	$0	$0	$0	$0	$0
Income & SS Taxes (Cash & Non-Cash)							
Net income after taxes		$0	$0	$0	$0	$0	$0
Retained Earnings		$0	$0	$0	$0	$0	$0

Statement of Owner Equity

		Dec. 31 2003	Dec. 31 2004	Dec. 31 2005	Dec. 31 2006	Dec. 31 2007	Dec. 31 2008
Beginning Net Worth (Cost/Mrkt)		$0	$0	$0	$0	$0	$0
Retained Earnings	+	$0	$0	$0	$0	$0	$0
Non-Business Inflows/Income	+	$0	$0	$0	$0	$0	$0
Owner Withdrawals	-	$0	$0	$0	$0	$0	$0
Contributed Capital	+						
Capital Distributions	-						
Change in Val. Equity (IF @ Mrkt)	+						
Calculated Ending Net Worth	=	$0	$0	$0	$0	$0	$0
Reported Ending Net Worth (Cost/Mrkt)		$0	$0	$0	$0	$0	$0
Discrepancy		$0	$0	$0	$0	$0	$0

Additional Detail Needed for Ratios

	Dec. 31 2003	Dec. 31 2004	Dec. 31 2005	Dec. 31 2006	Dec. 31 2007	Dec. 31 2008
Value of Operator and Unpaid Family Labor & Management	$25,000	$25,000	$25,000	$25,000	$25,000	$25,000
Payment on Operating Debt Converted to Term from Previous Years	$0	$0	$0	$0	$0	$0
Total Annual Payments on Personal Liabilities	$0	$0	$0	$0	$0	$0

Figure 5. Sweet 16 – Financial Measures for multi-year enterprise analysis

Financial Performance Ratios

Sweet		End of Year 2003	End of Year 2004	End of Year 2005	End of Year 2006	End of Year 2007
	Liquidity Measures					
1	Current Ratio	0.00	0.00	0.00	0.00	0.00
2	Working Capital	$0	0.00	0.00	0.00	0.00
	Solvency Measures					
3	Debt/Asset Ratio					
4	Equity/Asset Ratio					
5	Debt/Equity Ratio					
	Profitability Measures					
6	Rate of Return on Business Assets					
7	Rate of Return on Business Equity					
8	Operating Profit Margin Ratio					
9	Net Business Income	$ -	$ -	$ -	$ -	$ -
	Repayment Capacity Measures					
10	Term Debt and Capital Lease Coverage Ratio					
11	Capital Replacement and Term Debt Repayment Margin	$ -	$ -	$ -	$ -	$ -
	Financial Efficiency Measures					
12	Asset Turnover Ratio					
13	Operating Expense Ratio					
14	Depreciation Expense Ratio					
15	Interest Expense Ratio					
16	Net Business Income From Operations Ratio					

DETERMINING ECONOMIC BENEFIT OF DIAGNOSTIC STRATEGY
Once the cost of the disease is determined (either by partial budget or multi-year enterprise analysis), the cost effectiveness of alternate diagnostic testing strategies can be compared with a partial budget. In this partial budget, the post-test predictive values, test cost, cost of the negative condition, treatment cost, and cost of false positives are used to calculate the return for true positives, true negatives, false positives, and false negatives. The economic benefit is simply the costs for true negatives, false positives, and false negatives subtracted from the return for true positives.

Figure 6. Diagnostic testing partial budget

Disease Diagnostic Cost/Benefit Calculator

Single-Test Strategy

Test Sensitivity (%)	99.00%
Test Specificity (%)	99.50%
Prevalence (%)	1.00%
Cost of diagnostic test per head ($)	$10.00
Cost of Disease per head infected	$2,000.00
Cost of treatment for test-positive animals (direct Tx for tested Dz)	$0.10
Cost of False Positive (purchase price, lost income, disposal, etc.)	$550.00

Outcome from Initial Test

Positive Predictive Value (Initial test)	66.67%
Negative Predictive Value (Initial test)	99.99%
Value of Identifying True Positive (Initial test)	$1,989.90
Value of Identifying True Negative (Initial test)	-$10.00
Value of False Positive (Initial test)	-$560.10
Value of False Negative	-$2,010.00
Cost / Benefit of testing - Single test ($ / head)	$6.88

Details:	% of animals	If test 100,000 head	Value
True Positive	0.99%	990	$19.70
True Negative	98.51%	98,505	-$9.85
False Positive	0.50%	495	-$2.77
False Negative	0.01%	10	-$0.20
Total:	100.00%	100,000	$6.88

For conditions that are rare (low prevalence), the post-test predictive value of a positive test will be low, meaning that there will be many false positive results. In contrast, for conditions that are very common (high prevalence), the post-test predictive value of a negative test will be low, meaning that there will be many false negative results. In both situations, a partial budget evaluation is likely to indicate little or no economic benefit for a testing strategy. However, because some of the relatively infrequent negative conditions of interest to theriogenologists can have significant production and economic costs when present (infectious disease causes of infertility or pregnancy loss, subfertile bulls in single sire pastures, etc.), the cost of an infrequent but significant condition can be better evaluated as an assessment of risk and cost of risk avoidance. Once the cost of the risk is quantified, the producer and veterinarian can determine the effects such an event would have on a confined period's cash flow, and can evaluate that effect with the cost of risk reduction.

SYSTEM EVALUATION

How will the information from a diagnostic test be used?: Flaw of using partial budgets to determine economic value for diagnostic tests used to monitor a system

Like many diagnostic procedures that veterinary practitioners perform, pregnancy status determination may or may not be evaluated properly with a partial budget. The appropriateness of a partial budget is determined by how the information will be used. If one is using pregnancy detection to "salvage" the condition of cows being open (i.e. marketing, winter cow feeding, etc.) then the cost of the condition and the cost of correct and misdiagnosis (false positive or false negative) can be quantified (feed costs, replacement costs, salvage value, etc) and a partial budget is appropriate. On the other hand, if pregnancy detection is used to monitor the system of getting cow pregnant in a timely manner, then the false positives and false negative results for pregnancy determination are no longer solely based on individual cows, but also on whether the pregnancy distribution histogram is correct. If the system is incorrectly diagnosed as "broken", then unnecessary costs for diagnosis, nutritional consulting, feed changes, etc. are incurred. If the system is incorrectly diagnosed as "OK", then achievable production levels will not be reached, causing a significant reduction in gross and net income. In these cases a multi-year enterprise budget evaluation is necessary to estimate the value of a strategy to monitor reproduction by determining pregnancy status.

Breeding soundness examinations of bulls provide another example. When evaluating the economic return for BSEB, there is a cost for misdiagnosing (false positive or false negative). This cost shows up clearly in one-bull operations. However, this cost is different when comparing a multiple bull operation and a single bull operation, and different depending on whether the breeding pastures are single- or multiple-bull pastures. Therefore, when used to monitor a multiple-bull production system, the cost of BSEB testing is not defined by the cost of correct and incorrect tests, but rather by whether the testing adequately monitors the system.

An additional value for individual diagnostic procedures is the value of an observant veterinarian getting on the farm and evaluating the cattle, the farm, and the production system. This type of value is very difficult to determine even with a multi-year economic analysis or with a risk evaluation, because the risk reduction or production enhancement may be completely unknowable. Because this value cannot be determined by a partial budget, we as practitioners must not value ourselves only by doing partial budgets on short-term, knowable outcomes for the procedures we perform.

I propose that too many veterinarians have been conditioned to think that if we don't find problems, then we don't provide any value (partial budget thinking). W. Edwards Deming, who introduced statistical control of modern manufacturing, utilizes monitoring systems where many samples are taken, and yet very few are expected to indicate the presence of a problem. Deming's strategy starts with the end of the process (what will be produced) and determines what is needed to consistently make that product. Appropriate points in the process that are critical for the consistent production of the end product are measured. The Deming method develops a system where, by the middle of the process, one expects to rarely find a problem, however, monitoring continues in order to test the integrity of the system.

In this scenario, asking the value of an individual test or procedure is not appropriate, in that it has no value outside the system. Only the system has value and when one system is compared to an alternative system, a multi-year whole farm analysis or risk assessment is necessary and a partial budget is not appropriate.

Proposed method to determine the economic value for diagnostic tests that are used to monitor a system

Practitioners should help design production systems for their clients that optimize economic output. Each system will define the number of cows, distribution of calves at birth, number of bulls used, as well as the cost and genetic value of the bulls, the stocking density on grazing land, supplemental feed cost, and marketing timing. Varying inputs to the extremes of reasonable or expected ranges and determining the effect of the range of each input on the profitability of the operation and allows one to determine the most sensitive and important inputs to measure. The most sensitive inputs, and/or the measurements that predict their value, are then monitored. In cow-calf herds, these may include, body condition score, BSEB, pregnancy percentage, weaning percentage, weaning weight (genetics, stocking density, etc.), feed costs, and market price. At the most sensitive control points, the diagnostic strategies that most accurately monitor the points are often the most cost effective. If other, less expensive (to the veterinarian) and less accurate diagnostic tests are available for a specific control point, the system should be evaluated when using the alternate tests, and the test that results in the highest return for the system should be implemented.

Once the best-cost individual tests are determined, the value of all the diagnostic tests in the system is defined as the difference between the value of the system and an alternate system that lacks diagnostic monitoring. Because the system itself determines the value, the battery of tests required by the system should be offered and valued to the client as a group, not as individual diagnostic tests.

SUMMARY

Theriogenologists have been misled to believe that we must do partial budgets to determine our worth to clients. The problem with this approach is that although partial budgets are appropriate to evaluate production enterprises that can be completed in a relatively short time period (planting to harvest, finishing floors, feedlot pens, etc.), it is difficult for a partial budget to capture economic differences when comparing alternate multi-year production enterprise systems (herds of reproducing females). In addition, partial budgets are not appropriate to evaluate monitoring strategies for production systems. The values of diagnostic procedures commonly used in bovine theriogenology are difficult to accurately pinpoint especially when unknowable risks and production enhancement are considered. When used to monitor production systems, reproductive diagnostic procedures will usually be undervalued by a simple partial budget.