Selection Decisions: Tools for Economic Improvement Beyond EPD

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Throughout this manual, the goal has been to improve the profitability of beef production through proper sire selection and genetic improvement. The first step in using genetic improvement to increase profitability is to identify the economically relevant traits, the ERT, or those traits that directly influence the sources of income and/or the costs of production. To make this identification, the producer must consider how they market their animals, the performance of their animals, as well as the role of their product in the industry. For instance, is their primary income from the sale of breeding animals, as is the case with seedstock producers, or is income primarily from the sale of animals that are ultimately destined for harvest and consumption, such as is the case with commercial producers?

Once the breeder has identified the ERT that are appropriate for their production system, typically the number of EPD of relevance has been reduced considerably, yet even after that reduction, there still remains a considerable number of EPD to consider. Given that multiple traits likely need simultaneous improvement, an objective method for determining relative importance and economic value of each trait would further ease the animal selection process. Recently, new decision support tools have been released to the beef industry to address precisely this issue—determining relative importance and economic value of each trait and ultimately easing the process for making profitable selection decisions. To fully understand the utility and application of these advanced selection tools, breeders need a basic understanding of two concepts: 1. Single-trait selection and its weaknesses, and 2. Methods for multiple-trait selection which consider the production system, but may not address the economic value of each trait. Understanding of these two concepts, provides a foundation upon which to base improvements in selection methodologies. This chapter outlines the pitfalls of single-trait selection, considers different methods for multiple-trait selection, and ends with guidelines for use and evaluation of the next generation of selection tools for improving profitability of beef production.

Single- and Multiple-Trait Selection

Single-trait selection can produce rapid genetic change. Consider how frame size has changed from the 1960's to now—originally moving from small animals to the large frame scores seen in the 70's and 80's, and back to the more moderately sized animals today. No doubt, selection works.

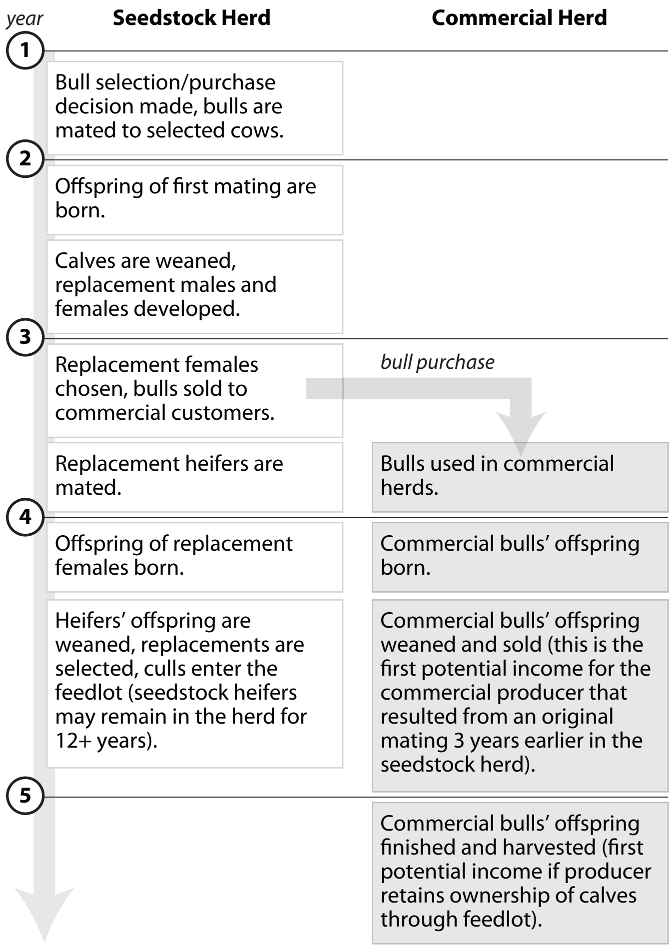
Unfortunately, single-trait selection typically results in undesirable changes in correlated traits as well. For instance, at the same time the industry was focused on changing frame size, mature weight and cow maintenance requirements were changing as well because they were genetically related, or correlated, to frame score. As a result the single-trait selection for increased frame size resulted in greater feed requirements and eventually in animals that were not well suited for many environments. Those not suited often ended up as thin cows, who were invariably late bred or not pregnant at all. Another unwanted change resulting from single-trait selection on frame score was an increase in birth weight and calving difficulty. All of these were the result of correlated response to single-trait selection on frame size. Single-trait selection is not advisable--breeders must approach genetic improvement from a systems perspective and change many traits simultaneously to achieve the goal of improved profitability.

Multiple-trait selection, considering more than one trait at a time, is the first step towards a systems perspective, but even multiple-trait selection leaves the breeder with several challenges. First, as additional traits are emphasized in a selection program, the rate of improvement in any one trait decreases. Second, the unfavorable correlations between many traits are still present. For instance, there is an unfavorable genetic correlation between calving ease and weaning weight both of which are ERT in many production systems. Calving ease tends to decrease as weaning weight is increased. This introduces a new problem—which of these two traits should be emphasized most in a genetic improvement program? These two problems are difficult to overcome without more sophisticated multiple-trait selection tools.

The best methods for evaluating a genetic improvement program's effects on profitability also consider the effects of time. The length between the selection decision and payback resulting from that decision often spans many years, and in a perfect system, the potential effect on profitability would be evaluated before the selection decision is made. Take the example of a breeder who is selling weaned calves and retaining a portion of the heifers as replacements; the sale weight ERT is weaning weight, but weaning weight is positively (and unfavorably) correlated to mature weight, an indicator of cow maintenance requirements. Selection for increased weaning weight will increase mature size and milk production, thereby potentially increasing the overall feed requirements of the herd over time and in turn, increasing costs of production. This scenario illustrates the need for selection decisions and genetic improvement goals to be evaluated in the context of the complete timespan for ramifications of the selection decision. Many producers do not consider the long-term effects of a selection decision, but rather consider what that particular sire will add to next year's calf crop.

From an industry-wide perspective, the potential impacts from a single selection decision made by the seedstock breeder requires considerable time before those superior genetics are realized by the seedstock breeder's commercial customer as illustrated in Figure 1. The seedstock breeder makes a selection and mating decision in spring, the offspring are born the following year and weaned. Bull calves are selected for development in that same year. In year 3, the bulls chosen for development are sold and used in the commercial herd. The offspring of these commercial matings are born in year 4. If those offspring are sold as weaned calves, the first income for the commercial producer arrives 4 years after the seedstock breeder's original selection decision.

Figure 1. Timeline illustrating time for the commercial producer to realize effects on profitability from a selection decision made in the seedstock supplier's herd.



If the commercial producer retains ownership of the calves, the first income may not be realized until year 5. So a mating in a seedstock herd made this year, may not realize income for the commercial producer until year 5.

The illustration in Figure 1 does not begin to consider the long-term effects of replacement females kept in the seedstock or the commercial herd. Assuming cows may reach 12 years of age before being culled, the original selection decision in year 1 may influence calves produced 16 years after the seedstock breeder's original decision if we consider the female replacements. As will be outlined below, good selection decision tools consider the long-term effects of selection decisions.

There are a variety of traditional methods for multiple-trait selection, many of which are implemented by producers, although they may not use this terminology to identify their methods. Each method has strengths and weaknesses.

Multiple-Trait Selection Methods

Tandem selection—Perhaps the simplest method for multiple-trait selection is tandem selection. With this method, just like a tandem axle truck or trailer, selection for one trait is followed by selection for another trait. All selection pressure is put on a single trait of interest until the performance of the herd reaches a level that the breeder desires, at which point another trait upon which to focus selection is chosen. For instance, a breeder may put all emphasis on improving marbling until a target level for percent choice is attained. At that point, the breeder realizes that performance in another trait, such as growth, needs improving and subsequently changes selection focus from marbling to growth. This method is rarely used in a strict sense because selection on one trait often produces unfavorable change in correlated traits as we discussed earlier. As a result, maintaining acceptable production levels for all traits is difficult with this method. The single scenario where this method is used considerably is for cases where some animals are culled at weaning and then the remaining group is culled further at a year of age.

Independent culling—The second and likely most common method for multiple-trait selection is independent culling. With this method, a breeder chooses minimum or maximum levels for each trait that needs to be improved. Any animal not meeting all criteria is not selected for use in the breeding program. To illustrate, consider a herd where the average weaning weight EPD is +25 and the average birth weight EPD is +1. If the producer is interested in improving weaning weight but does not want to increase birth weight, that producer might set a minimum threshold of a +35 WW EPD and a maximum BW EPD threshold of +1. Any potential sire not meeting both of those criteria would not be selected. Clearly, there are more than just 2 important traits as in this example, and accordingly as additional traits are added to the breeding objective (traits of interest), culling levels are set for each. This method is widely used due to the ease of implementation. Most breed association websites provide tools for sorting bulls on EPD with a user-defined set of standards (minimum and/or maximums). Using these web-based tools is analogous to implementing the independent culling method of multiple-trait selection.

Determining the appropriate culling level or threshold for each breeder is the most difficult aspect of this method as objective methods for identification are not widely available. Another drawback of this method is that as additional traits are added, criteria for other traits likely must be relaxed in an effort to find animals that meet all criteria. In the above WW/BW example, consider adding another trait such as marbling score EPD. If the breed/population average is +.06, the breeder might want to select only sires with a minimum marbling score EPD of +.5. To meet this marbling score standard, the weaning weight standard may have to be lowered to +30 (from the original +35) and the birth weight raised to a +2 (from the original +1). This "lowering of standards" reduces the rate of progress in any one trait, similar to other multiple-trait methods. However, once thresholds are identified, application of this method is very easy, making this method quite popular.

One major disadvantage to both tandem selection and independent culling is that neither of these methods incorporate the costs or income resulting from production—they do not account for the economic importance of each trait, and as a result do not simplify the evaluation of potential replacements based on probable effects on profit. The foundational method for overcoming this problem and for incorporating the economics of production into selection decisions and genetic improvement was developed by Hazel (1943) and is commonly referred to as selection indexes.

Incorporating Economics Into Multiple-Trait Selection

Hazel developed the concept of aggregate merit which represents the total monetary value of an animal in a given production system due to the genetic potential of that individual. Henderson (1951) reported that the same aggregate value could be calculated through weighting EPD by their relative economic value. These EPD, weighted by their relative economic values are summed to produce the aggregate value for each individual. Historically, the greatest challenge for the delivery of these indexes has been the determination of the economic values for weighting the EPD (or traits). The economic value for an individual trait is the monetary value of a one-unit increase in that trait, while other traits directly influencing profitability remain constant. For instance, the economic weight for weaning weight would be the value of a one-pound increase in weaning weight, independent of all other traits, or put another way, the value of a one pound increase in weaning weight holding all other traits constant. This may seem relatively straightforward, but problems arise in the ability to accurately assess value and changes caused by genetic correlations. Relative to assessing the value of a one pound increase in weaning weight it must be recognized that increases in weaning weight result in increased feed requirements, partially offsetting the increased income from the greater weaning weights. Accounting for these increased costs and revenue from improved weaning weight in an effort to derive the economic value is difficult at best.

The estimation of the relative economic values requires detailed economic information on the production system. Because costs of production change from producer to producer, these economic values also change from producer to producer. In some regions, breeders may have access to relatively cheap forages or crop aftermath during winter whereas others may be forced to buy relatively expensive, harvested forages to maintain the cow herd during these forage shortages. In these two scenarios, the value, or cost, associated with increases in maintenance feed requirements are not the same. The difficulty in obtaining detailed economic and production information from individual breeders has resulted in the development of generalized indexes that use information from surveys of groups of producers and/or governmental statistics on prices received and costs of production. While this is a very good alternative to breeder-specific indexes, the use of this generalized information can result in misleading economic weights from one production enterprise to the next. For instance, the relative economic value of calving ease depends upon the current levels of calving difficulty in a herd. Consider an extreme example, one producer assists no heifers during calving and another has a 50% assistance rate, the former would have a relatively low economic value for calving ease as current levels warrant no additional genetic change, whereas the last producer would put considerable economic value on genetic improvement of calving ease. A result of the requirement for detailed economic information has produced low adoption rates for many indexes. Additionally, many breeders are reluctant to use indexes because they feel indexes remove control over the direction of genetic change in their herd. Simply put, indexes take the "art" out of animal breeding.

Even with low adoption rates, those breeders and producer groups that have chosen to implement such indexes have witnessed rapid genetic and economic improvement. There are two documented examples of the genetic improvement resulting from the implementation of this technology. The first of these was reported by MacNeil (2003) and was based on an index of

$$I = \text{yearling weight} - (3.2 * \text{birth weight})$$

as proposed by Dickerson et al. (1974). This index was designed to improve the efficiency of beef production by 6% as opposed to selection on yearling weight alone. The index was calculated to reduce increases in birth weight and associated death loss resulting from the increase in yearling weight and to simultaneously reduce increases in mature weight and feed requirements usually associated with increasing yearling weight. After 11 years of selection based on this index, MacNeil et al. (2003) reported positive genetic change in direct and maternal effects on 365-day weight and a negligible, slightly positive change in birth weight. MacNeil also implemented independent culling levels for birth weight and yearling weight in another selection line. The independent culling line exhibited no increase in birth weight, but the increase in yearling weight was only half of that achieved with index selection (MacNeil et al., 1998).

Selection index technology was also implemented in 1976 by a New Zealand ranching firm, Landcorp Farming, Ltd. In that year, the company began selecting animals in their Angus seedstock herd for an economic breeding objective developed by Morris, Baker and Johnson and described by Nicoll, et al. (1979). The breeding objective was defined as

$$H \text{ (Net Income (\$ per cow lifetime))} = 0.53*L*D_P*(4.8*F-1)+0.06*M*D_M$$

Where:

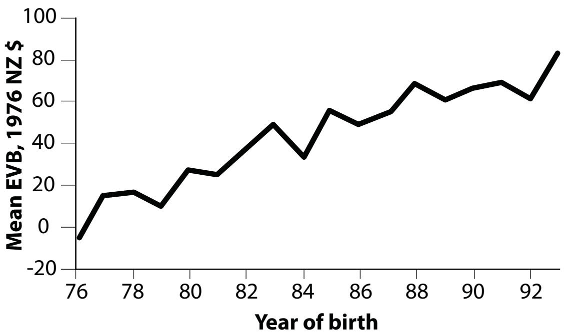
0.53	=	the net income (1976NZ$/kg carcass) from the slaughter of young stock;
0.06	=	the net income (1976NZ$/kg carcass) from the slaughter of cull cows;
L	=	slaughter weight (kg) of surplus progeny at 30 months of age;
D_P	=	dressing percentage (x 0.01) of slaughtered progeny;
D_M	=	dressing percentage (x 0.01) of the culled cow;
F	=	net fertility; and
M	=	weight (kg) of cow at disposal.

(All of the above dollar values are in 1976 New Zealand dollars, but in the end, currency does not matter—the systems work the same).

The value for 4.8*F represents the total number of saleable calves per cow lifetime. One was subtracted from this total to account for the cow's replacement in the herd. Costs of production and income were based on data from the New Zealand Meat and Wool Boards' Economic Service and are reported in New Zealand dollars. Selection on this breeding objective resulted in simultaneous improvement in direct and maternal weaning weight, yearling weight, number of calves weaned per cow, and overall aggregate merit (Figure 2). As in the previous index where birth weight remained relatively stable and yearling weight increased, in this breeding system mature weight was remained relatively constant while early growth increased.

In both of the examples above, breeding programs that implemented selection indexes achieved rapid genetic gain and were able to hold traits of particular importance relative to costs, birth weight and mature weight, relatively stable.

Figure 2. Genetic trend in aggregate breeding value (New Zealand $) during 17 years of index selection.



Selection index technology is also used in many other animal industries including the pig, poultry, and dairy industries. In the hog industry, application of these technologies in one breeding program has resulted in nearly $1 more profit per head marketed per year (Short as quoted in Shafer, 2005).

Application of Selection Index Methods in North America

In North America, several breed associations publish index values for a variety of production systems. These include maternal, terminal, and pre-identified finish endpoint indexes. Within each category, the specificity of the available indexes varies. At one end a "generalized" index, usually developed by a group of producers or a breed, is meant to fit the needs of all members of the group. At the other end of the spectrum are indexes designed for use in specific production systems with specific production costs, revenue streams, and performance levels. At the extreme, this end of the continuum results in a specialized index for each breeder's specific production system, so that a seedstock producer might have a different index appropriate for each of their customers' production systems, hence the term "specialized". While specialized indexes represent the best implementation, development of specialized indexes for every producer or customer is likely cost and time prohibitive. Because of these difficulties, most published U.S. beef breed association indexes are generalized--some more than others. Hereafter the term "generalized" index will be used to refer to an index that is designed for use across multiple breeders for specific marketing situations. It is beyond the scope of this manual to review every index currently published and with the anticipated release of more indexes by several associations, such a discussion would be outdated very quickly after publication. This discussion will be limited to suggested "points of consideration" to be used when evaluating strengths and weaknesses of association-provided indexes or to decide whether to implement selection on a particular index or not.

The first step is to identify the most appropriate index for a particular breeder or production system (or your production system). To successfully execute this step the breeder must have identified the primary use of their market animals (breeding or harvest). If the breeder is a seedstock producer, they should be considering how their customers, the commercial producers, will be marketing the offspring of the animals the seedstock breeder wishes to sell. If the breeder is a commercial producer, they must consider how the offspring of those sires will be marketed. The age at which those offspring will be marketed, and the end purpose of those market animals are also important considerations. For instance, different traits will likely be emphasized if animals are marketed at an auction, through private treaty, or on the rail for quality or yield grids. A cow/calf producer selling weaned calves anonymously through an auction would likely select a weaned calf index as opposed to an index that assumes that animals will be marketed on a grid basis. Similarly, a producer retaining ownership on calves and subsequently marketing those on a muscle (yield) grid, would not base selections on an index which assumes marketing on a quality grid, nor would that producer use a weaning index. Essentially identification of the appropriate index starts with the identification of the economically relevant traits for that producer's production system (as outlined in the previous chapter) and is followed by selection of the index that includes those economically relevant traits. Just like using the ERT to reduce the amount of information that must be considered when making a selection decision, the goal of any index is to combine information on individuals in the form of EPD to make selection more straightforward. Use of an inappropriate index may not produce genetic improvement that yields greater profit.

The other important component necessary to choose the appropriate index is considerations of the current genetic and production level of the herd. For instance if replacement heifers are kept from within the herd, do they have high conception rates as yearlings? What percentage of calving difficulty does the herd experience? Knowledge of these production characteristics helps determine the appropriate index and helps determine whether (as will be discussed below) other criteria should be included in making selection decisions beyond the index.

Criteria for Evaluating Indexes

Many indexes are produced by breed associations and may or may not include all of the traits that are economically relevant to a particular production system. When deciding on the use of generalized indexes several criteria must be available for the breeder to evaluate utility of each index in their production system. If these criteria are not available then application of those indexes should be limited at best. At minimum a description of every index should at a minimum include the first 3 items below and preferably the 4th:

1. Traits included in the index,
2. Description of information used in the index, such as EPD from a breed evaluation or individual phenotypic performance,
3. Source of economic information and performance levels used to calculate economic weights, and preferably
4. Relative economic emphasis of each trait to the overall index.

The reasons behind the first requirement are obvious, without knowing the traits included in an index, a producer can not decide whether it's use is appropriate or not. In a perfect world, the index would contain all of the traits that are economically relevant for the breeder's system. Unfortunately, this scenario is unlikely and the breeder should identify the index with the most traits in common with their list of economically relevant traits. The second item above is needed as use of EPD is always a more accurate form of selection than use of phenotypic information.

The reasons behind third and fourth requirements are less obvious and best explained with an example. Consider two breeders where one has access to relatively cheap crop aftermath to graze cows during the winter while another producer is limited to purchasing rather expensive harvested forages. The cost associated with increased maintenance requirements is different for the two breeders and similar economic values on maintenance requirement (or mature weight) would not be appropriate. Point 4 further refines the selection of the appropriate index. For instance, a typical index for selecting animals to produce slaughter progeny that are marketed on a quality grid would include marbling score in the index. For a producer whose slaughter cattle consistently grade 95%+ choice, more selection pressure on marbling score is unwarranted and marbling score should receive less emphasis if any. This producer would likely rather hold marbling score constant while improving other traits such as growth rate or time on feed. Point 4 provides information on the relative importance of traits in an index—which trait is most emphasized, which is second, and so on down to the least emphasized trait. Economic weights can be expressed as a dollar value or as a relative weight indicating the emphasis placed on each trait. A breeder would not likely choose an index that puts most emphasis on a trait that is of little value to that production system, or is already at an optimum level in their own herd.

In comparison to how long EPD have been available, the development and application of indexes in the U.S. beef industry is in its infancy. As more indexes are developed and released, however; the producer will also want to consider the relative importance of each trait in the index (points 3 and 4). This is one of the deficiencies of generalized indexes—rarely are they appropriate for every breeder due to the differences between the relative importance emphasized in the index and reality for the breeder. They are typically most appropriate for the overall genetic improvement of a breed as a whole. Until more specialized indexes are developed, the producer likely can not consider the source of data used to calculate the economic weights or the relative importance of each trait in the index. Additionally, most indexes released as of this writing do not have published relative economic weights for each trait as there have been concerns voiced over the proprietary nature of that information.

Once the appropriate index has been selected, strict application of the index system would necessitate that sire selection decisions be made solely on this information. Realistically, there are other issues to be concerned with such as breeding soundness, structure, and economically relevant traits not in the index. For traits not in the index, the breeder will need to apply appropriate selection pressure in addition to that on the index.

The successful application of generalized indexes relies upon the logical implementation as outlined below:

1. Identify your production and marketing system
   a. When will the animals be marketed (at what age)?
   b. How will the animals be marketed (private treaty, public auction, etc)?
   c. What is the current performance and genetic level of your herd?
2. Identify an index appropriate to the production system outlined in #1
   a. Questions to be addressed
      - What traits are included in the index?
      - What are the relative economic values used to weight the traits (or at least what data is used to estimate cost of production and value of income sources)
3. Decide on the appropriate index for evaluation based on the most similarity between points 1 and 2.
4. Evaluate index based on past performance and economic data (very difficult, so is listed as "optional")

For those skeptical of index selection, item number 4 provides a measure of confidence in a particular index, answering the question "Does this index produce results consistent with my production system?" A "cowboy" evaluation of an index's usefulness would include using historical performance and income data from sire-identified animals in the herd. The sire-identified animals chosen should have been marketed in a manner similar to that in the chosen index. The producer could then calculate an average value for each sire's progeny within a contemporary group. Once these averages are calculated, determine the difference in gross income between the sires' progeny averages. If available, calculate the costs of production for each sire's progeny groups and the net income for each sire group. The difference in net income (or gross income) should rank sires similarly to the rankings provided by the index value. The actual differences in profitability may not be as exact as those predicted but rankings should be similar. As with EPD, small contemporary groups or relatively few animals available for comparison reduce the confidence in this "cowboy" method. Larger contemporary groups are more informative and provide higher levels of confidence in the comparisons. This type of ad hoc evaluation becomes more difficult and less precise for cow/calf producers who retain female replacements. The primary difficulty is in evaluating changes in cow feed requirements and in length of productive life. To appropriately evaluate such indexes our recommendation is at least 6 years of cow data, and preferably more, be used to evaluate the applicability of any index where replacement heifers are retained. Admittedly, this method does not satisfy the requirements of strict academicians, but if validated with performance and economic information from contemporary animals, confidence should increase in the use of a specific index.

Breeders often ask what are the risks associated with using an index that incorrectly weights traits. Fortunately, small errors in economic weights are likely to have little effect on overall genetic improvement provided no single trait dominates the index (Smith, 1983; Weller, 1994). Problems arise when a single trait dominates an index and large changes occur in the importance of that trait.

Another issue not addressed in the above that may arise with the release of multiple, generalized indexes by a single breeding group is the potential for "double counting" and overemphasizing a particular trait. For instance, let's assume an index is being used that is appropriate for a cow/calf operation marketing weaned calves, and retaining replacement females and the index accounts for changes in feed requirements in the cow herd. If the breeder then also selects on another index that also accounts for genetic changes in feed requirements, the breeder could be overemphasizing the importance of feed requirements. In this case, it would likely result in over-penalized animals with greater growth potential. Again, selecting the single most appropriate index, is the best approach for implementation of this technology.

There are problems inherent with selection indexes as outlined above. Most of these deal with the use of generalized indexes rather than specialized indexes and incorrect economic values for each trait. In the ideal situation all economically relevant traits will be included in an index. Not including an economically relevant trait in an index is the same as assuming the value of improving that trait is zero unless the producer includes that trait in selection decisions along with the index values. The next section discusses other options for sire selection that overcome many of the problems with generalized selection indexes.

Beyond Indexes—Advanced Decision Support Systems

The development and use of selection indexes is increasing rapidly and is a considerable improvement over any other multiple-trait selection method previously available. Yet, indexes still have weaknesses. Of the currently available indexes most are generalized for overall breed improvement and use average costs and incomes from production rather than accounting for specific producer's marketing and production systems. More advanced selection support tools that offer breeders increased flexibility through interactive computer systems are becoming increasingly available. This "next generation" of selection tools is rapidly being released by various breed associations, but currently only several options exist for North American production systems. Each of these will be briefly discussed, but given the brisk pace at which new tools are being developed and improved, the majority of the following will focus on application and appropriate use of these tools.

Interactive decision support tools overcome the weaknesses inherent in generalized indexes. The term "interactive" refers to systems that allow the producer to input parameters specific to their production systems. These interactive systems offer increased flexibility to simulate individual breeders' production systems, and allow evaluation of the long-term effects of selection decisions and evaluation of the risks associated with particular selection decisions.

There are two general classes of interactive decision support systems. The first are herd-level systems that require herd-wide biological inputs and costs and incomes of production and in turn, return herd-wide results. These systems are designed to evaluate overall change in genetic level rather than to evaluate potential individual selection decisions and to uncover important interactions between genetic level and environment. Systems of the second type are animal based and predict outcomes of individual selection decisions and the potential consequences of using an animal (or animals with similar EPD) over the long term scenario. Because the former do not evaluate individual selection decisions they will only be briefly discussed here.

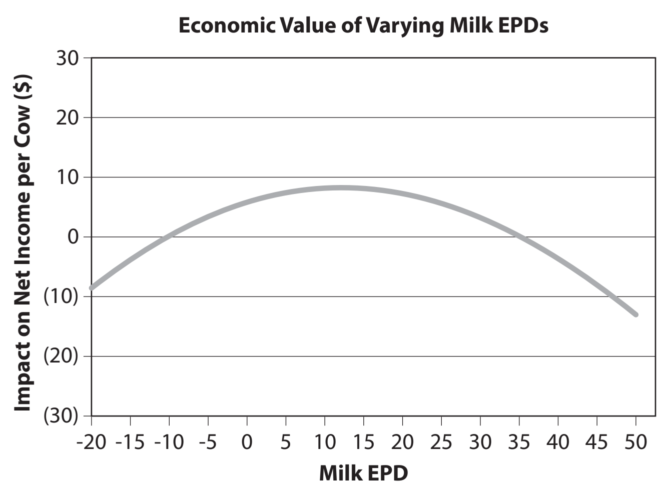
The first class of decision support systems includes the Decision Evaluator for the Cattle Industry or DECI and the American Angus Association's Optimal Milk Model. The DECI system is available through the website, http://www.ars.usda.gov/services/software/software.htm. The tool was developed for managers to "evaluate strategic decisions affecting productivity and profitability through multiple marketing endpoints for an individual herd of breeding females". This system does not evaluate the consequences of individual selection decisions but rather evaluates the overall effects of changing genetic levels of a herd between three options: low, medium, and high. (The system will also evaluate changes in management of the herd such as changing supplementation levels or calving seasons). For instance, the system was designed to compare the option of using moderate growth sires versus high growth sires in a production system where feed resources are limited and heifers are retained from within the herd as replacements. In this system a baseline herd that represents the current herd structure, performance, and costs and product value is parameterized. Once the base herd is parameterized modifications to the genetic level and/or management procedures are evaluated through their overall effect on herd profitability. Additionally, specific herd production parameters such as weaning weight, calving weight or cow body condition score can be monitored over the course of the simulation.

The Angus Optimal Milk Module (www.angus.org/Performance/OptimalMilk/OptimalMilkMain.aspx) takes a similar approach, providing a tool designed specifically for producers to decide the appropriate range of milk EPD given the mature weight of their cows, annual cow costs, and variability in feed resources. The system produces output estimating cost of feed energy per Mcal and useful recommendations for an optimal range of milk EPD for that specific operation. Additionally, graphical outputs are available that illustrate the effect of increasing/decreasing milk EPD on net income per cow as shown in Figure 3.

Individual-Sire Decision Support

The second class of decision support systems is designed for evaluating individual animal selection decisions, and the impact of those decisions on profitability. These systems are based on breeder-specific production and economic data. Currently, only two systems exist with this flexibility and that are available to all commercial producers. These are located via the web at www.charolaisusa.com (Terminal sire profitability index) and ert.agsci.colostate.edu. The latter will be known as the ERT tool and the

Figure 3. Example of graphical presentation of results from the Angus Optimal Milk Module.



former as the terminal system (TS). Both systems are designed so that the breeder need only input critical performance, cost and product value (income) data (Table 1). These limited data ensure that the tool is as easy to use as possible while retaining flexibility to simulate different production systems.

The TS is designed to evaluate decisions for selection of sires in the American International Charolais Association database based on their relative impact on profitability in a terminal sire mating system. By definition no replacements are kept from within a terminal mating system. The TS allows input of current herd production characteristics and sources of income by the producer including options for weaned calves, backgrounded calves, and grid pricing models. Sires are then ranked by their index values given the producer's production values. This system offers increased flexibility over selection indexes by allowing producers to select animals based on their specific production system. The terminal system accounts for increased feed requirements for animals sired by bulls with greater levels of growth, but does not account for differences in costs of production. The TS also assumes that are calves are marketed on a carcass value basis.

Table 1. Example input information required for use of terminal sire and ERT (cow/calf) decision support systems

		ERT (cow/calf)	
Category	**Terminal Sire**	**Observed Performance**	**EPD**
Animal performance	• Cow Size • Weaning weight • Backgrounding phase ADG • Growing phase ADG • Finishing phase ADG • Marbling Score • USDA Yield Grade	• Herd Size • Mature cow calving rate • Heifer calving rate • Mature Cow Weight • Calf Survival Weight • Yearling weight • Weaning weight • Birth Weight • Heifer calving difficulty	• Birth weight • Weaning weight • Yearling weight • Milk • Calving Ease Direct • Heifer Pregnancy • Calving Ease Total Maternal • Stayability • Maintenance
Management Information	• Length of Backgrounding phase • Length of growing phase • Length of finishing phase	• Input goal • Replacement source • Cows per bull • Breeding system • Maximum cow age	
Economic Information	• Cull cows, $/cwt • Weaning Price $/lb (sliding scale) • Backgrounding Price, $/lb	• Non-feed cow costs • Value of bred heifers • Value of bred cows • Value of herd sires • Heifer price • Cull cow price • Calf price • Replacement heifer price • Cost of additional feed • Discount Rate	
Carcass Grid Information	• Base price, $/cwt • Light and heavy carcass, weight breaks and discounts • Quality grade discounts and premiums • Yield grade discounts and premiums		

The current ERT system is designed to evaluate selection decisions for the cow/calf producer marketing weaned calves. This system requires inputs on the production system, management specifications, genetics, and economics of production. The tool has been designed for both commercial and seedstock breeder with basic data requirements that should be readily available for most producers. The system produces data for evaluating the consequences of a particular selection decision both on a performance basis and on an economic basis. The outputs are based upon the current genetic level of the herd and changes resulting from selection of a particular sire. The system relies on a database of EPD from participating breed associations and allows comparison of animals within breeds.

Given advances in flow of performance data between industry sectors and advances in the development of decision-support systems, more of these decision tools will likely be released to the industry in the near future. As with any new technology breeders must have faith in the tool and also have some method to evaluate the technology. When EPD were originally delivered to the industry, that tool also needed such scrutiny and eventually became widely accepted. From a scientific standpoint, the ultimate testing of any decision-support product, whether selection index or interactive decision support, would be peer-reviewed studies on the utility of each system in a research setting. Research herds typically are able to record much more detailed information than is cost effective for the average producer. The deficiency of such studies is that they represent the environment and production system in which they were validated. Additionally, these studies take time to generate and publish. Given the dynamic beef industry, producers need some method to evaluate the utility of these for their own production system.

The following is a suggested protocol for evaluation of these systems for specific production systems. The points outlined below are much like those outlined for evaluation of selection indexes. Realize that some decision support systems will account for production changes that are not readily quantified by every breed association genetic evaluation. For instance, these systems will likely account for change in feed requirements, something not easily measured by most commercial producers, and therefore difficult to translate into profitability. Each point will be discussed subsequently.

An outline of steps for evaluation of interactive decision support tools (discussion follows):

1. Identify production and marketing system
   a. When will the animals be marketed (at what age)?
   b. How will the animals be marketed?
   c. What is the current performance and genetic level of your herd?
   d. Gather historical cost and income data on the herd of interest (relative to the required inputs for step 2)
2. Enter herd parameters into decision support system
3. Simulate your current herd
4. Evaluate results
   a. Consider the following:
      - Does the system accurately predict animal performance (may or may not be an outcome of an interactive system)
      - Does the system accurately predict economic performance (may or may not be produced—interpret carefully as most producers will likely not have all performance information needed to precisely evaluate the system)
5. Enter EPD for currently used bulls (or select those bulls) and calculate results of those selections.
6. Compare results for bulls used in number 5 to actual results.
7. Use system to identify potential sire selection decisions.

Step 1 is similar to that used for evaluation of selection indexes. As with any decision support tool, specifying the production and marketing system is critical for evaluation and successful use of selection tools. Selection of the appropriate selection tool begins with identification of a system that closely resembles the producer's production and marketing system. For instance, a producer would not want to use a selection tool that assumes marketing finished animals on a carcass basis, if that producer actually markets weaned calves through an auction system. Step 2 is self-explanatory. Steps 3 through 4, may or may not be available depending upon the system. Some systems such as DECI and ERT provide performance and outputs on the current herd structure. The TS requires input of bulls used in the past if the user wishes to evaluate the system's representation of a current production system (Step 5). In theory, a terminal-sire breeder could input the terminal sires they have used in the past, and then compare the actual performance of those bulls' progeny to the differences predicted by the TS system (Step 6). Step 6 is critical for evaluation of the selection system—does the tool rank animals and profitability similarly to historical performance? If the system closely resembles past performance (using historical inputs), the user has much more faith in the system and can proceed to Step 7. Step 6 must be implemented with the realization that the producer may not have all of the needed information to fairly evaluate the decision support tool. The economic and animal performance data available for the producer may not be as detailed or as accurate as required for a "fair" evaluation of the system. As previously mentioned, values for changes in feed requirements will very likely be missing. If retaining replacement heifers, likely data on female lifetime productivity will be lacking, making appropriate evaluation of the decision support system difficult. If the data to evaluate the system are suspect or deficient, then the producer should not lose confidence in the system. Similarly to when EPD were first introduced, the most detailed analysis of the results of these systems and the verification of their utility will be performed through research facilities. Several studies with the primary goal of validating these systems are currently underway.

Conclusion

The goal of both selection indexes and interactive decision-support systems is to ease the process of multiple-trait selection and to combine the economics of production with selection to improve profitability. The successful use of either selection indexes or interactive decision- support systems depends upon selection of a system that simulates a specific production and marketing system. Selection of the appropriate index or interactive system is key to success. With the application of one of these systems both the commercial and seedstock producer should increase profitability. Two studies described within showed great progress using only phenotypic data, not the much more accurate EPD available today. Use of these systems will also make selection and marketing of animals more straightforward and simple.

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