Chapter 3

Beef Cattle Selection

The goal of beef cattle production is to provide highly desirable beef for consumption in the most efficient manner. Knowledge of breeding, feeding, management, disease control and the beef market is fundamental to the economical production of desirable beef.

The beef cattle industry is composed of six basic segments: (1) the purebred breeder, (2) the commercial producer, (3) stocker or backgrounding operations, (4) the cattle feeder, (5) the beef packer and (6) the retailer. The purebred breeder maintains seedstock to provide bulls and, occasionally, females for the commercial producer. The commercial producer provides feeder calves and yearlings to the stocker operator who, in turn, furnishes the cattle feeder who provides the packer with finished cattle ready for slaughter. The packer slaughters the cattle and provides the retailer with either dressed carcasses or wholesale cuts from these carcasses. The retailer cuts, trims and packages the beef for the consumer. Interdependence exists among these segments because each affects cost of production or desirability of product or both. The profits that accrue to all segments of the beef cattle industry depend on continued improvement in productive efficiency and carcass merit.

Major Performance Traits

All traits of economic value should be considered when selecting beef cattle. The major traits influencing productive efficiency of desirable beef are:

- reproductive performance or fertility
- maternal ability
- growth rate
- feed efficiency
- body measurements
- longevity
- carcass merit, and
- conformation or structural soundness

Maximum production efficiency is not necessarily related to maximum performance levels in all of these traits due to unfavorable genetic associations between certain traits. For example, high levels of milk production and large cow size are associated with rapid growth rate in the calf but are not desirable when feed supplies are limited because reproduction in the cow is adversely affected.

Fertility

A high level of fertility, or reproductive performance, is fundamental to an efficient beef cattle enterprise. Fertility is commonly measured in terms of calf crop percentage, and no single factor in commercial cow-calf operations has greater bearing on production efficiency than the number of calves weaned per cow in the herd. The percentage calf crop can easily range from 70 to 95 percent. However, as noted in Table 4-1 in Chapter 4 (Animal Breeding), the heritability of calving interval or fertility is low (10 percent). Therefore, most of the variation in calving percentage results from environmental factors such as feeding, management or herd health.

Fertility is a complex trait. Many environmental and genetic factors affect fertility from the time a cow is turned with a bull until her calf is weaned. Basic cow herd records should report calf crop percentage to determine if a problem exists. Where fertility or calf crop percentage is low, very detailed records should be kept on reproductive traits to identify management, nutrition, herd health or genetic problems that can be modified to improve reproductive performance in the herd.

The association between fertility and other performance traits, both positive and negative, should be recognized. For example, selection for heavy weaning weight can result in increased milk production or larger cow size in the herd or both and necessitate a higher nutritional level for the cow herd to maintain a satisfactory fertility level. On the other hand, culling open cows or problem breeders to improve reproductive performance in the herd with no regard for the specific cause for low reproductive performance will decrease the average milk production and cow size in the herd. Also, increased birth weight is associated with increased rate of gain and mature size. Calving difficulty as a result of heavy birth weights can cut deeply into calf crop weaned by reducing calf survival at birth and conception rate in the cow the following breeding season.

Maternal Ability

The ability of a cow to wean a healthy, vigorous calf is vital to efficient beef production. Increased milk production increases weaning weight per calf, and heavier weaning weights can increase efficiency of production in relation to fixed costs for the total herd.

However, feed requirements and costs per cow are closely related to cow size and level of milk production. Thus, milk production must be matched with feed resources to maximize efficiency of production. Optimum milk production is neither maximum nor minimum milk production in most situations. Increased weaning weight per calf from milk production can be detrimental if weaning weight per cow is reduced as a result of poor rebreeding performance or market value is diminished by a wasty condition.

Growth Rate

Growth rate is important because of its high association with economy of gain in relation to fixed costs. Growth rate has usually been measured in time-constant, post-weaning feeding tests. A reasonably high level of feeding for at least 112 days is desirable to appraise differences in growth rate most accurately.

Genetic correlations among measures of growth or size at different ages usually are high. Selection for rapid rate of gain in post-weaning feeding tests usually increases both birth weight and mature size. Increases in birth weight contribute to increased calving difficulty. Increased mature size decreases carcass quality when slaughtered at normal market weights and increases the nutrient requirements for maintenance of the cow herd.

Ideally, the beef animal should be of moderate weight at birth, grow rapidly, but mature and finish for slaughter early. But, the selection criterion to obtain such a growth curve is complex.

Feed Efficiency

Feed efficiency is a trait of great economic importance in beef cattle. Feed efficiency is difficult to evaluate because individual feeding and adjustments for differences in weight are required. Increased weight is associated with higher feed requirements per unit of gain. To be meaningful, feed efficiency should be measured in feeding tests designed within the framework of present-day cattle feeding and marketing practices.

Breeders largely depend on differences in rate of gain as an indicator of feed efficiency rather than incur the added expense of individual feeding. Some bull testing stations obtain individual feed consumption information to measure the pounds of feed required per pound of animal gain.

Body Measurements

Objective body measurements can be useful selection aids. Some common measurements of cattle include backfat, height at the shoulder, height at the hips, length of body, depth of body, scrotal circumference and pelvic size.

Linear body measurements are helpful in matching mature animal size to production resources. Body measurements were never intended to be used only for the purpose of selecting for a larger size. These measurements should also never be interpreted as a replacement for the weight of a beef animal at a given age. No one specific size for an animal will be ideal for all feed and management resources, breeding systems and feed costs. Reproductive rate and market weight ultimately determine the optimum range in size for a given set of feed and management resources, breeding systems and production costs.

Hip height measurement is the most commonly used body measurement in selection programs. The recommended point for measurement of height is directly over the hip bones, or hooks (Figure 3-1). These measurements may be converted to frame scores using the bull and heifer hip height tables in the Appendix.

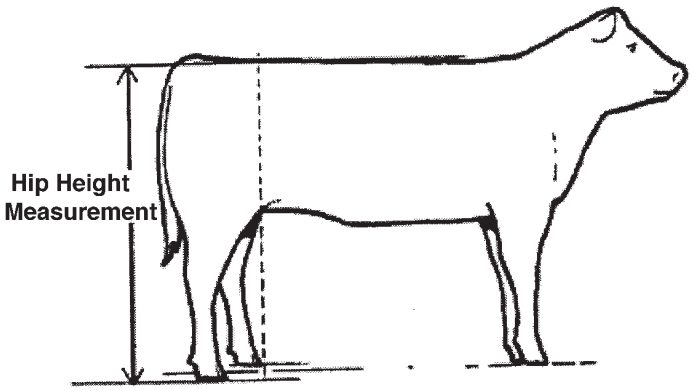


FIGURE 3-1. Hip height measurement.

Longevity

The longer animals remain productive in a herd, the fewer replacements will be needed. Thus, the cost of growing replacements to productive age is reduced. Longevity is especially important in the commercial cattle herd.

The major factors affecting longevity of cows are infertility, unsoundness of feet and legs, udder troubles and unsound mouth.

Purebred breeders should be concerned with making genetic improvement in longevity for the benefit of the commercial beef cattle population. However, animals retained in purebred herds to an old age increase the generation interval which reduces the possible rate of genetic improvement from selection. Selection for longevity should be confined primarily to such indicators as structural soundness.

Carcass Merit

Carcass merit is of basic importance to the beef cattle industry. The desirability of the beef product

determines the price consumers are willing to pay and the amount they are willing to purchase at that price.

Consumers desire beef with a high percentage of lean as compared to fat and bone, and the lean must be tender, flavorful and juicy. The difference in the percentage of lean, often called cutability, is a major factor influencing differences in carcass value. It is not uncommon for carcasses of the same quality to range from 10 to 30 percent fat trim. However, such differences in composition are due to both environmental and genetic variations.

Beef quality, which includes such characteristics as tenderness, flavor and juiciness, can have an important influence on consumer acceptance and value. Beef quality is determined by marbling, texture, color, firmness and maturity.

The genetic association between cutability and quality is negative. Selection for high quality will usually diminish cutability, and selection for high cutability will often lower beef quality. Also, selection for rate of gain or mature size often will diminish carcass quality.

Conformation and Structural Soundness

Conformation and structural soundness are performance traits to the extent that they contribute to functionality and longevity, feed efficiency and carcass merit. Conformation in live cattle is normally a subjective evaluation of thickness of natural fleshing or muscling. Differences in conformation or muscling can be used to reflect potential differences in carcass cutability without having to obtain carcass data. Also, feed efficiency relates to muscling among cattle of similar growth pattern and mature size. Structural soundness is particularly important for productive grazing and pasture breeding. Sound hips, hocks, shoulders and feet are valuable for longevity in the herd.

Selection Methods

Three approaches to selection are (1) tandem selection, (2) selection based on independent culling levels and (3) selection based on an index of net merit.

Tandem is selection in which useful traits are selected sequentially. When the desired level of performance is reached in one trait, a second trait is given primary emphasis, etc. This is the least effective of the three types of selection. Its major disadvantage is that by selecting for only one trait at a time, other traits may suffer as a result. This method of single trait selection is not recommended.

Selection based on independent culling levels requires that specific levels of performance be obtained in each trait before an animal is kept for replacement. This is the second most effective type of selection. However, selecting for specific levels of performance in all traits does not allow for slightly substandard performance in one trait to be offset by superior performance in another.

Selection based on an index of net merit gives weight to the traits in proportion to their relative economic importance and their heritability and recognizes the genetic association among traits. This can be the most effective type of selection, but the importance of each individual trait in the index should vary depending upon the needs and desires of each individual producer. This balanced selection approach considers multiple economically relevant traits at one time. The dollar ($) EPDs that many breed associations calculate are based upon this selection principle.

Buying a Herd Bull

Purchasing the next herd sire is one of the most important decisions that a cattle producer makes. Because every calf in the herd gets half of its genetic makeup from the sire and half from its dam, the sire is said to be half the herd. In actuality, studies of selection experiments have shown that the sire may be responsible for as much as 90 percent of the change in a trait such as weaning weight. The sire influences the herd in two ways. First, he changes the current calf crop. Secondly, he influences later calf crops through daughters that are retained for use as brood cows. The sire's influence may be either in a positive or negative direction. A commercial cattle producer should consider many questions when buying a bull.

1. Should I buy a performance-tested bull?

Performance testing is nothing more than keeping a record of performance on the traits of interest and using these records to make selection decisions. Performance testing programs provide cattle producers with reliable information for identifying animals with superior genetic potential for the traits of production measured by the test. By using the information as a basis for herd sire selection, a breeder can greatly increase the chances of obtaining a bull that will sire rapid-gaining, more efficient, high-quality calves. Such calves can increase profits for both the breeder and the feeder.

2. Do I buy a young bull or an older proven bull?

Usually more weanling and yearling bulls are available to select from than older, proven bulls. Obviously, more performance information is available on an older bull; but in some cases, the older bull is for sale because of poor performance. Occasionally, an

outstanding older bull is for sale by a breeder that has retained replacement heifers from him. Usually, buying yearling bulls will offer the greatest number of bulls with the most complete records from which to select. Use of virgin bulls is helpful in limiting the introduction of diseases into the breeding herd.

3. What performance information should I expect?

The records maintained by purebred breeders range from none to very elaborate record keeping systems. Basic performance information should include birth date, birth weight, weaning weight, yearling weight and number in the contemporary group on all bulls. Sufficient records to evaluate the bull's sire and dam are preferred. Expected progeny differences (EPDs) are a valuable selection tool that should be used when available. Structural soundness, type and conformation can be evaluated visually. Always conduct a breeding soundness evaluation on yearling or older bulls.

4. What performance levels should I require in the bull?

When selecting a herd sire, buy bulls that are above average of the respective breed in the traits of interest. Individual records are meaningful but may be greatly influenced by the environment in which the bull was tested. Comparison to other animals tested in the same environment provides some indication of genetic difference. EPDs give estimations of genetic merit for many economically relevant traits and allow comparisons to be made between bulls within the same breed or with breed averages.

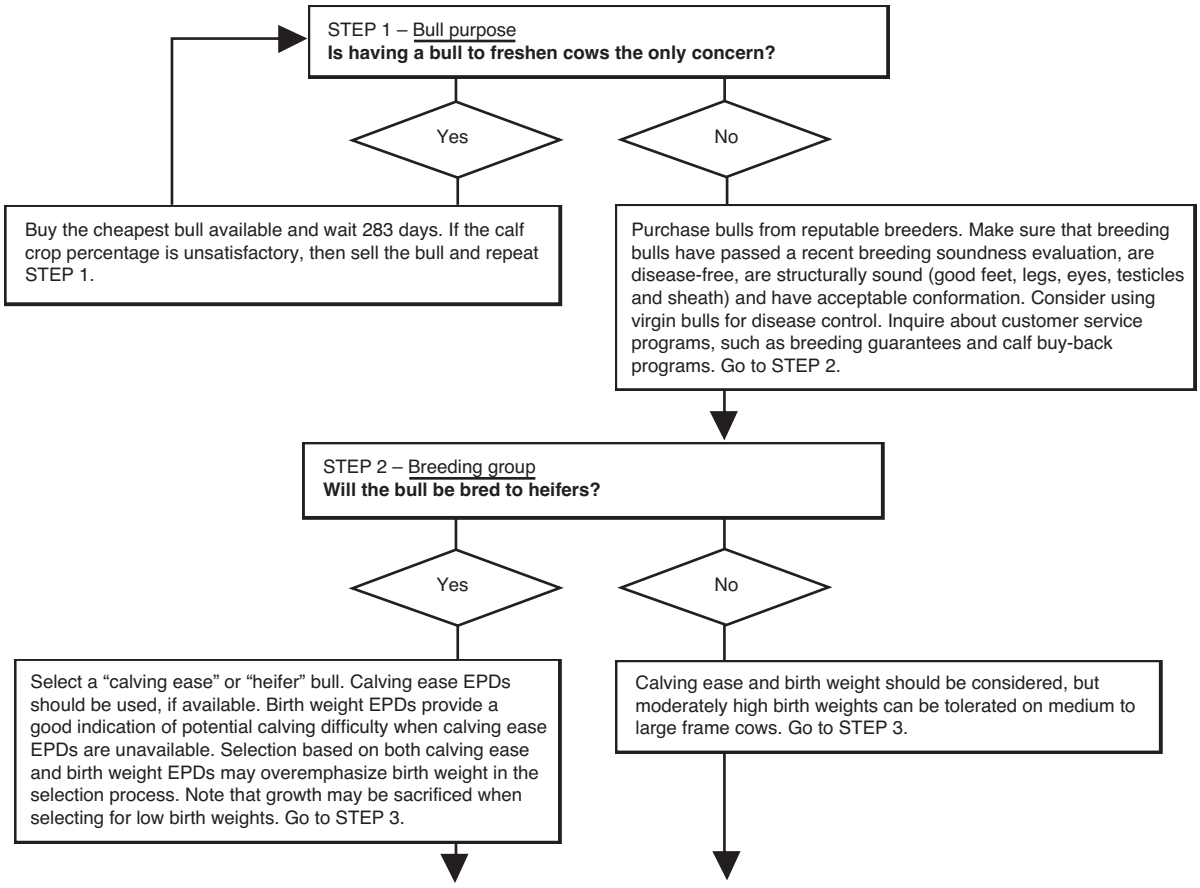
5. What about performance by the bull's sire and dam?

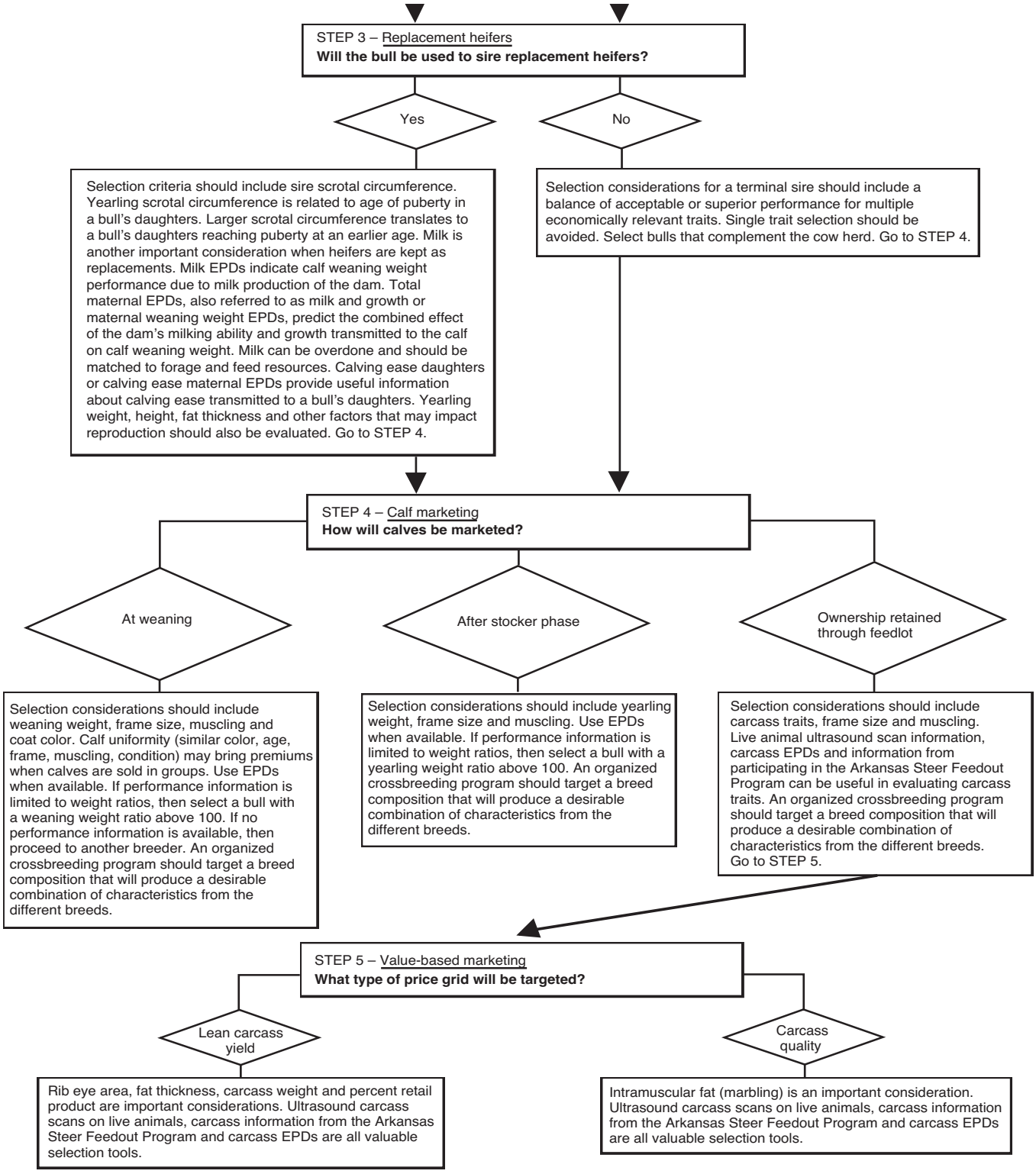
The herd sire should come from a cow that has been a regular producer, has consistently weaned calves heavier than the herd average and is strong structurally. The sire should be an outstanding individual in the desired performance traits and should have proven ability to transmit his characteristics to his offspring.

6. How much is a bull worth?

Performance information along with EPDs gives an indication of the expected performance of a bull's calves for particular traits such as growth performance relative to the performance of calves sired by

FIGURE 3-2. Bull Selection Decision Flow Chart




STEP 3 – Replacement heifers
Will the bull be used to sire replacement heifers?
Yes
No
Selection criteria should include sire scrotal circumference. Yearling scrotal circumference is related to age of puberty in a bull's daughters. Larger scrotal circumference translates to a bull's daughters reaching puberty at an earlier age. Milk is another important consideration when heifers are kept as replacements. Milk EPDs indicate calf weaning weight performance due to milk production of the dam. Total maternal EPDs, also referred to as milk and growth or maternal weaning weight EPDs, predict the combined effect of the dam's milking ability and growth transmitted to the calf on calf weaning weight. Milk can be overdone and should be matched to forage and feed resources. Calving ease daughters or calving ease maternal EPDs provide useful information about calving ease transmitted to a bull's daughters. Yearling weight, height, fat thickness and other factors that may impact reproduction should also be evaluated. Go to STEP 4.
Selection considerations for a terminal sire should include a balance of acceptable or superior performance for multiple economically relevant traits. Single trait selection should be avoided. Select bulls that complement the cow herd. Go to STEP 4.
STEP 4 – Calf marketing
How will calves be marketed?
At weaning
After stocker phase
Ownership retained through feedlot
Selection considerations should include weaning weight, frame size, muscling and coat color. Calf uniformity (similar color, age, frame, muscling, condition) may bring premiums when calves are sold in groups. Use EPDs when available. If performance information is limited to weight ratios, then select a bull with a weaning weight ratio above 100. If no performance information is available, then proceed to another breeder. An organized crossbreeding program should target a breed composition that will produce a desirable combination of characteristics from the different breeds.
Selection considerations should include yearling weight, frame size and muscling. Use EPDs when available. If performance information is limited to weight ratios, then select a bull with a yearling weight ratio above 100. An organized crossbreeding program should target a breed composition that will produce a desirable combination of characteristics from the different breeds.
Selection considerations should include carcass traits, frame size and muscling. Live animal ultrasound scan information, carcass EPDs and information from participating in the Arkansas Steer Feedout Program can be useful in evaluating carcass traits. An organized crossbreeding program should target a breed composition that will produce a desirable combination of characteristics from the different breeds. Go to STEP 5.
STEP 5 – Value-based marketing
What type of price grid will be targeted?
Lean carcass yield
Carcass quality
Rib eye area, fat thickness, carcass weight and percent retail product are important considerations. Ultrasound carcass scans on live animals, carcass information from the Arkansas Steer Feedout Program and carcass EPDs are all valuable selection tools.
Intramuscular fat (marbling) is an important consideration. Ultrasound carcass scans on live animals, carcass information from the Arkansas Steer Feedout Program and carcass EPDs are all valuable selection tools.

another bull or group of bulls. Using this information, educated purchasing decisions can be made regarding the purchase price differences that can be justified when comparing bulls. To illustrate differences in bull value, the following is an actual scenario from the Livestock and Forestry Branch Station in Batesville, Arkansas. Bull A and Bull B were exposed to cows of similar genetic merit. Bull A sired calves that weighed on average 436 pounds at weaning. Calves sired by Bull B weighed 543 pounds on average at weaning.

Weaning weight difference between Bull B and Bull A = 543 pounds - 436 pounds = 107 pounds

Lighter-weight calves typically sell at a higher price per pound than heavier-weight calves. If calves sired by Bull A could be sold for $2.20 per pound and calves sired by Bull B could be sold for $2.08 per pound, then gross returns from each bull would be as follows:

Bull A: 436 pounds x $2.20 per pound = $960 per calf sold

Bull B: 543 pounds x $2.08 per pound = $1,130 per calf sold

The difference in gross returns per calf would then be:

$1,130 (Bull B) - $960 (Bull A) = $170 per calf

If each bull can be expected to sire 25 calves per year, then the difference in gross returns per year between the two bulls would be:

$170 per calf x 25 calves per year = $4,250 per year

Over 5 years, the difference in gross returns between the two bulls would be:

$4,250 per year x 5 years = $21,250

If Bull B costs $2,000 more than Bull A, then one-half of the additional income from the first calf crop would pay for the cost difference to acquire the superior bull:

$2,000 ÷ $4,250 = 0.47

By using Bull B as a herd sire, a producer can more than justify paying the $2,000 premium for him over Bull A. This ignores interest and depreciation costs and assumes that there are only weaning weight differences in the calves sired by the two bulls. If Bull B is also superior to Bull A in his ability to transmit heavier muscling, enhanced carcass characteristics or other economically important traits to his calves, including the improvement in heifers kept for replacement, then an even higher premium may be justified over the same payback period. This illustrates the financial importance of making bull-purchasing decisions based on as much useful and reliable information as is available.

7. What is the reputation of the herd from which selection is made?

The honesty and integrity of the owner and manager, the overall performance of the herd and the management practices under which the bull has been developed are extremely important to the prospective bull buyer.

Selecting Replacement Heifers

These traits should be considered when selecting heifers from the herd for brood cow replacements: (1) reproductive performance in the heifer's dam, (2) maternal ability of the heifer's dam, (3) weaning weight and yearling weight of the heifer, (4) conformation and (5) soundness.

When the heaviest heifers are selected at weaning, the results are improved maternal ability and growthiness in the herd. Heifers which fail to grow and develop after weaning should be culled at breeding time. Conformation is best evaluated after the heifer has reached yearling age. The third selection can be made after the heifers wean their first calves. Remove heifers that either fail to calve or produce poor calves. Generally, the first calf is a good indication of a cow's production in succeeding years.

For a 100-cow herd, about 16 heifers will usually be needed for replacements each year to maintain numbers. More than 16 may be needed if considerable culling is done at breeding time and after the first calf.

Performance Records

The University of Arkansas System Division of Agriculture's Cooperative Extension Service can assist beef cattle breeders with developing a systematic set of performance records. It also can help in utilizing these records in decisions relative to individually defined objectives within their breeding programs. Defined objectives and a planned breeding program are fundamental to attaining the maximum rate of genetic improvement in economically important traits in beef cattle. An organized improvement program with selection based on differences in records is basic to any planned breeding program.

Success in breeding superior beef cattle depends on the ability of the breeder to make accurate decisions while working toward his objectives. The more a breeder knows about the individuals in his herd and the more clearly he understands his objectives, the more likely he is to make correct decisions. Records from a complete improvement program provide the basis for making accurate decisions. A breeder's objectives for improvement can be reached only through a planned breeding program based on the use of performance data in selection.

Performance records should have flexibility and be helpful to both purebred and commercial cattle producers for comparing cattle within the same herd, breed, sex, age group and management group (Figure 3-3). Performance records are not designed for estimating differences between herds or between groups managed differently within a herd because environmental differences are likely to exist.

FIGURE 3-3. Weighing calves and measuring hip height for performance testing.

Two types of performance testing programs are available to beef cattle breeders who may use them collectively to monitor each animal's performance from birth. The two types that should receive emphasis by cattle breeders are (1) cow herd performance testing and (2) on-farm bull testing.

When performance data are maintained, they can be a valuable aid in (1) measuring progress in herd improvement, (2) evaluating performance of herd sires, (3) culling poor-producing cows, (4) selecting replacement females, (5) selecting bull calves for testing, (6) selecting future herd sires and (7) determining structural soundness under standardized conditions.

Contact your county Extension office for more information about performance testing.

Expected Progeny Differences (EPDs)

Throughout history, geneticists have studied methods for use in identifying superior individuals in beef cattle populations. Sire selection has tremendous value to the beef cow-calf operation. Choices of herd sires not only have an impact on the resulting calf crops, but these choices also affect the performance of the cow herd if daughters of the sires are kept as replacement heifers. Ideally, beef producers would like to select sires of desirable genetics for genetic improvement in economically important traits. Selection of desirable genetics to match with a cow herd is a challenging task. Fortunately, the concept of breeding value provides beef producers an avenue to make useful selection decisions. The background on breeding value estimation leads to a better understanding of the merit of Expected Progeny Differences (EPDs).

Background on Breeding Value Estimation

Breeding Value

Breeding value is defined as the value of an individual as a parent. Parents transfer a random sample of their genes to their offspring. Estimated breeding value gives an estimate of the transmitting ability of the parent.

Expected Progeny Difference

One-half the estimated breeding value is equal to the Expected Progeny Difference (EPD). The word "difference" implies a comparison. Thus, EPDs let us compare or rank the superiority of individual animals. EPDs provide a prediction of future progeny performance of one individual compared to another individual within a breed for a specific trait. The EPDs are reported in plus or minus values in the units of measurement for the trait. For example, birth, weaning and yearling weight EPDs are reported in pounds. As a common rule, the EPD values may be used to compare only those animals within a breed. For example, the EPD values for a Hereford bull may not be compared against the EPDs for an Angus or Limousin bull. However, new across-breed EPD adjustment values are now available that make it possible to compare EPDs on animals of different breeds.

Genetic Evaluation

The first beef cattle national sire summary was published in 1971 by a breed association. Up until the first summary, only within-herd comparisons of breeding value could be made for a given year, season and contemporary group. The national sire summaries in the early '70s and subsequent summaries allowed cattle within a breed to be compared across herds, generations and regions of the United States. These evaluations by individual breeds were National Sire Evaluations (NSE). However, the NSE concept had some problems.

1. Bulls had to have progeny information in order to be included in the evaluation. This meant that only older bulls were published in the summaries.
2. No adjustment was made for the mating of superior cows to the bulls represented in the evaluation. The purebred breeders saw this as a big problem.
3. Progeny records were used in the evaluation, but the individual record on a bull was not included.
4. Breeding values were calculated on sires in the evaluation, but no genetic values were computed for dams.

A mathematical model, called the Animal Model, was developed in the mid-1980s to correct the problems associated with NSE. Use of the Animal Model required extensive calculations. To reduce the number of equations that needed to be solved in an evaluation, the Reduced Animal Model (RAM) was developed. This approach reduced the amount of computer memory necessary to run the genetic evaluation.

The theory behind RAM was developed much earlier, but the computer technology was needed to process large numbers of equations for many animals. With the advances in computers, major beef breed associations today conduct National Cattle Evaluations (NCE) rather than National Sire Evaluations (NSE) because of its superiority in genetically evaluating cattle within a breed. The beef industry had progressed into an era of computing EPDs for all animals within a breed, thus the terminology of cattle evaluation rather than sire evaluation was adopted.

National Cattle Evaluations conducted using RAM procedures calculate a genetic value for an individual within a breed, whether that individual is a sire, dam or nonparent animal. Any combination of pedigree, individual records and progeny information is included to derive breeding values for all animals in the evaluation. The breeding values are divided by two and reported as EPDs. The Animal Model approach adjusts for the merit of mates. Specific matings of inferior or superior animals are considered. Maternal genetic values, or Milk EPDs, may be computed for the maternally influenced trait, weaning weight. As with the previous evaluation (NSE), EPDs from the NCE are comparable across herds. Environmental and management differences are accounted for so that comparisons can be made.

Also, any genetic change within a breed for a particular trait is accounted for in the evaluation; therefore, comparisons may be made across generations of cattle. Young bulls with no progeny may be directly compared with older sires that have progeny.

Each EPD value should have an accuracy assigned to it. Accuracy is the measure of reliability associated with an EPD. It is expressed as a value between 0 and 1. A high accuracy (>.7) means a higher degree of confidence may be placed on the EPD and the EPD value is not expected to change much as further information is gathered. A low accuracy (<.4) means that the EPD may change a great deal as additional information is gathered.

Contemporary Group

In the collection of beef cattle performance information, breed associations realize that contemporary group definition is critical. A contemporary group is a group in which animals of a given sex and age, having similar treatment, are given the equal opportunity to perform (Beef Improvement Federation Guidelines, 1990). The basis of sound performance testing relies on correct identification of contemporary groups. Accuracy in estimation of genetic differences within a group of animals is dependent on accuracy of grouping.

Breeding value estimation in beef cattle has an important history. Developments in animal breeding theory and computer technology have provided beef cattle producers with a selection tool for comparison or ranking of individual animals within a breed. This selection tool is an Expected Progeny Difference (EPD). National Cattle Evaluations conducted by individual beef breed associations combine pedigree, individual records and progeny performance to compute EPDs. The use of EPDs allows producers to make selection decisions for beef cattle traits of economic importance.

Breed Average EPD and Base Year

It is frequently said that an EPD is a comparison to an average bull. This is **NOT** an accurate statement. A zero EPD represents the average genetic merit of

animals in the database at the time when there was sufficient information to calculate EPDs. Therefore, it represents a historic base point, or base year. Some breed associations now set the base year to a particular year. If the breed has made any genetic change for a trait, the average EPD for the trait will no longer be zero. Breed associations publish the average EPDs in the sire summaries made available to the public. Information printed in the summaries should be examined carefully before individual EPDs are studied.

Accuracy

Accuracy is the measure of reliability associated with an EPD. Each EPD value should have an accuracy assigned to it. It is expressed as a value between 0 and 1. A high accuracy (>.7) means a higher degree of confidence may be placed on the EPD and the EPD value is not expected to change much as further information is gathered. A low accuracy (<.4) means that the EPD may change a great deal as additional information is gathered. Nonparent animals have lower accuracy values since no progeny information contributes to their EPD. From a practical viewpoint, the EPDs are used to select bulls for use in the herd, and accuracies help determine how extensively to use the bulls in the herd. Some sale catalogs do not list accuracies with the EPDs. On young animals with no progeny data, such as yearling bulls, one would realize that accuracies would be low.

Possible Change Value

Possible Change is the measure of the potential error associated with EPD values. Many sire summaries are starting to include such values. Possible change is expressed as "+" or "-" pounds of EPD. These values quantify the amount a certain EPD may deviate from the "true" progeny difference. Accuracy and possible change values share a relationship. As more information is accumulated, accuracy increases and possible change diminished. For a given accuracy, the "true" progeny differences of two-thirds of all animals evaluated within a breed are expected to fall within the plus or minus possible change value. An example to illustrate this point follows:

Birth Weight EPD = +2.0 pounds
Accuracy = .60
Possible Change = + 1.3 pounds

Of all the animals with this EPD and accuracy, two-thirds of the animals are expected to have "true" progeny differences between +.7 and +3.3. These "true" differences have a much greater chance of falling toward the center of the range defined by the possible change value than falling close to the extremes. Also, one-third of the individuals in the evaluation may have their "true" progeny difference values fall outside the range of +.7 and +3.3. This means that one-sixth of the individuals may have "true" values less than +.7 and one-sixth of the individuals may have "true" values of more than +3.3.

Sire summaries include a sampling of the available genetic material in each breed. The summaries for breed associations that conduct National Cattle Evaluations come out at least once a year. Summaries include EPDs, accuracies, graphs of the average change in EPD for the particular breed, breed average EPDs, possible change values and other useful materials. Descriptive material written at the beginning of each summary describes the format for reporting the EPDs. An example of a sire summary is listed in Table 3-1. The example presents EPDs and accuracy values (ACC) for traits commonly found in most summaries.

At least 18 beef breed associations currently conduct National Cattle Evaluation programs. Almost all sire summaries include birth weight, weaning weight, yearling weight and milk EPDs. A few currently include some characteristics that have a role in reproduction such as calving ease, gestation length and scrotal circumference. Many of the breed associations are currently working to include some of these other characteristics into the summaries. There is a fairly large effort to incorporate more carcass information. Carcass evaluations may result in EPDs for carcass weight, rib-eye area, fat thickness and marbling score.

Many of the summaries contain two listings of bulls. The first is a listing of progeny-proven bulls. These are older bulls that have calves with performance records; therefore, the accuracies on the birth and weaning weight EPDs are generally at least .5. The second section is devoted to younger bulls that have lower accuracies (.3 to .5 on weaning and birth weight). The criteria for listing varies among the breeds.

TABLE 3-1. Example EPDs for Two Bulls

Sire	Birth Wt.		Weaning Wt.		Milk		Yearling Wt.	
	EPD	ACC	EPD	ACC	EPD	ACC	EPD	ACC
Bull 123	+4.0	.90	+24	.90	+12	.70	+50	.80
Bull 345	+2	.35	+12	.30	+5	.40	+23	.20

Growth Trait EPDs

EPDs provide a prediction of future progeny performance of one individual compared to another individual within a breed for a specific trait. The EPDs are reported in plus or minus values in the units of measurement for the trait. For example, birth, weaning and yearling weight EPDs are reported in pounds. The EPD values may be used to compare only those animals within a breed. In other words, the EPD values for a Hereford bull may not be compared against the EPDs for an Angus or Limousin bull. The EPD values are most useful when two individuals are being compared directly. For example, consider the two sires in Table 3-2 and assume that both sires are from the same breed and that the EPDs have equal accuracies.

TABLE 3-2. Example of Birth Weight EPD		
	Sire A	**Sire B**
BW EPD (LBS)	+5	-2

The expected difference in the progeny of Sire A and Sire B for birth weight is 7 pounds. Sire A has an EPD of +5 and Sire B has an EPD of -2. On the average, we should expect the calves by Sire A to be 7 pounds heavier at birth than calves of Sire B, if all the calves are managed uniformly and are from cows of similar genetic merit. The predicted performance difference is 7 pounds although it is not possible to estimate the actual birth weight average for these calves. The EPDs allow the prediction of performance differences, not actual performance.

Each individual member of a breed can have EPD values calculated for it. Purebred breeders report data to the National Herd Improvement Program for their breeds to contribute to the breed national database. Age and sex of a calf or status as a parent are not limiting factors. A newborn calf could be assigned EPDs. It is possible to compare any two members of the breed regardless of location, but comparisons cannot be made across breeds. Each individual has its own performance and the performance of progeny, sibs, parents, grandparents, etc., that can be utilized to evaluate genetic merit. New animal breeding and computer technology result in techniques whereby the performance of the animal and information on its relatives are included in the estimate of genetic merit. Thus, EPDs are available on parent and nonparent animals. This process involves extensive calculations which only the latest generation of computers is able to accomplish efficiently.

The EPD values are available for all animals, male and female. Preferential mating of certain individuals does not bias the results. A genetically superior bull can be mated only to genetically superior cows and his EPD will not be inflated. This is accomplished by adjusting for the EPDs of the cows to which he is mated. Appropriate adjustments are made for genetic trend. For example, this adjustment allows young bulls to be directly comparable to older bulls with many progeny records.

Table 3-3 is an example of Weaning Weight EPDs. It describes a weaning weight difference in the progeny of two bulls.

TABLE 3-3. Example of Weaning Weight EPD		
	Sire A	**Sire B**
WW EPD (LBS)	+25	-10

The expected difference in the progeny of Sire A and Sire B for weaning weight is 35 pounds. Sire A has an EPD of +25 and Sire B has an EPD of -10. On average, we should expect the calves by Sire A to be 35 pounds heavier at weaning than calves of Sire B, if all the calves are exposed to the same environmental conditions and are from cows with similar genetic merit. Table 3-4 is an example for Yearling Weight. It describes a yearling weight difference in the progeny of two bulls.

TABLE 3-4. Example of Yearling Weight EPD		
	Sire A	**Sire B**
YW EPD (LBS)	+50	+10

The expected difference in the progeny of Sire A and Sire B for yearling weight is 40 pounds. Sire A has an EPD of +50 and Sire B has an EPD of +10. On average, we should expect the calves by Sire A to be 40 pounds heavier at one year of age than calves of Sire B, if all the calves are managed uniformly and are from cows with similar genetic merit.

Maternal Trait EPDs

Maternal effects are an important consideration when evaluating beef cattle performance. Extensive studies have been conducted to quantify maternal effects for a variety of traits, especially those measured during the preweaning period. Phenotype is the physical expression of the genetic makeup of an animal. In beef cattle, the dam makes at least two contributions to the offspring phenotypic value. These contributions are the sample half of her genes passed

directly to the offspring and the maternal effect she provides her calf. A maternal effect is defined as any environmental influence that the dam contributes to the phenotype of her offspring. The contribution of the dam is environmental with respect to the calf (mothering ability, milk production, environment, maternal instinct). The genetics of the dam allow her to create this environment for her calf. Maternal effects are important during the nursing period with diminishing effects through post weaning.

Milk EPD

Weaning weight can be determined by the genes for growth in the calf and genes for milk (mothering ability) in the cow. There are separate EPD values for these two components. The Weaning Weight EPD evaluates genetic merit for growth, and the Milk EPD evaluates genetic merit for mothering ability. The Milk EPD that results from the separation of weaning weight into growth and milk segments is, like any other EPD, fairly simple to use. It is the expected difference in weaning weight of calves from daughters of a particular sire, due to differences in mothering ability. As an example, consider two bulls in Table 3-5.

TABLE 3-5. Example of Milk EPD

	Sire A	Sire B
EPD (LBS)	+10	-5

The expected difference in the progeny from daughters of Sire A and Sire B is 15 pounds. Sire A has a Milk EPD of +10; Sire B has a Milk EPD of -5. The expected weaning weight difference, due to mothering ability alone, in calves from daughters by the two bulls is 15 pounds. The 15 pounds are expressed in pounds of weaning weight, not pounds of milk.

Combined Maternal EPD

Combined Maternal EPD (sometimes called maternal weaning weight or total maternal) reflects both the milking ability transmitted to daughters and direct weaning growth transmitted through daughters to their calves. An example is illustrated in Table 3-6.

TABLE 3-6. Combined Maternal EPD

	Weaning Weight EPD	Milk EPD	Combined EPD
Bull A	+20	+12	+22
Bull B	+4	+6	+8
Combined (Bull A) = 1/2(20) + 12 = 22 Combined (Bull B) = 1/2(4) + 6 = 8			

Bull A has a direct Weaning Weight EPD of +20 pounds. This expresses the ability of the bull to transmit weaning growth directly to his progeny. On average, calves sired by Bull A should be 16 pounds heavier at weaning than calves sired by Bull B, assuming both bulls are mated to a comparable set of females and the calves are exposed to the same environmental conditions. The 16-pound difference in future progeny performance is due to genes for direct weaning growth. The Milk EPD for Bull A (+12) is the contribution to his daughter's calves solely through transmission of genes for mothering ability. The expected difference in the progeny from daughters of Bull A and Bull B is 6 pounds. Bull A has a Milk EPD of +12; Bull B has a Milk EPD of +6. The expected weaning weight difference, due to mothering ability alone, in calves out of daughters by the two bulls is +6 pounds. The Combined EPD for Bull A (+22) is computed by taking one-half the Weaning Weight EPD plus all the Milk EPD. The +22 pounds affect both the milking ability transmitted to daughters and the direct weaning growth transmitted through the daughters to their calves. In a similar method, the Combined EPD for Bull B is one-half times the Weaning Weight EPD plus the Milk EPD, or +8 pounds. An average difference of 14 pounds would be expected as the difference in weaning weight of calves out of daughters of the bulls based upon the genetic merit for growth (WW EPD) and milk (Milk EPD).

Calving Ease EPDs

Calving ease heritabilities have been reported to be small (.00 to .13) for beef cattle. The magnitude of the estimates indicates that little genetic progress can be made on selecting directly for calving ease. However, there are exceptions where calving ease heritabilities have been reported to be over .46 in particular studies. Some breed associations report Calving Ease EPDs along with Birth Weight EPDs while other associations' reports do not include Calving Ease EPDs. Breed associations that report Calving Ease EPDs may present them in different formats. Be sure to study the meaning of Calving Ease EPDs separately for each breed. Descriptive material written at the beginning of most sire summaries should be useful in interpreting the meaning of Calving Ease EPDs. Different breed associations may list the calving information in different formats.

Calving Ease EPDs are given in two ways: Calving Ease EPD and Maternal Calving Ease EPD. Calving Ease EPDs are expressed as deviation of percent of unassisted births.

When comparing EPDs of two animals, a larger EPD represents a higher percent of unassisted births. Calving Ease EPDs indicate the ease with which calves of a sire are born to first-calf heifers. Maternal Calving Ease EPDs are the ease with which daughters of a sire calve as first-calf heifers. These may also be given as the ease with which daughters of a sire calve as mature cows. When comparing sires, the larger EPD represents a higher percent of unassisted births for calves born from daughters of a bull.

Milk EPDs are widely available from beef cattle breeds. The values are expressed in pounds of weaning weight. Direct comparisons of Milk EPDs may be made between individuals within a breed. The Milk EPD is the expected difference in weaning weight of calves from daughters of a bull compared with calves from daughters of another bull, due to mothering ability. Beef producers may use Milk EPDs as part of their selection program when choosing bulls to sire replacement heifers for their herd.

The Combined Maternal EPD is another value available for use in sire selection. It is the sum of one-half the Weaning Weight EPD plus all the Milk EPD. The Combined Maternal EPD reflects both the mothering ability transmitted to daughters and direct weaning growth transmitted through daughters to their calves. Calving Ease EPDs are available and are correlated with BW EPD. Details about these values and their use should be studied before selection decisions are made.

$Value Indexes

These values are multi-trait selection indexes, expressed in dollars per head, to assist beef producers by adding simplicity to genetic selection decisions. A $Value has meaning only when used in comparison to the $Value of another animal. For example (Table 3-7), just as with EPDs, variation in $Values between animals indicates average expected differences in the relative value of progeny if random mating is assumed and the calves are exposed to the same environment.

TABLE 3-7. $Value EPD

$W	$F	$G	$B
+22.36	+14.26	+12.53	+26.25

Weaned Calf Value ($W) is an index expressed in dollars per head. This is the expected average difference in future progeny performance for preweaning merit. $W includes both revenue and cost adjustment associated with differences in birth weight, weaning direct growth, maternal milk and mature cow size.

Feedlot Value ($F) is an index that includes adjustments associated with postweaning performance and predicts the variation in value between sires.

GridValue ($G) is an index that includes adjustments associated with carcass grid merit and predicts the variation in value between sires

Beef Value ($B) is the expected average difference in future progeny performance for postweaning and carcass value compared to progeny of other sires. The $B value combines the contributions of $F and $G.

The values are not designed to be driven by a single trait, as an index is multi-trait by design. These selection tools are the result of the application of industry-relevant market values to genetics for preweaning, feedlot and carcass merit. These values should be used to complement the criteria that producers already use when selecting bulls. These are $ indexes reported by the American Angus Association. However, many breed associations are now reporting $ index values, and some come with different definitions than the ones that are listed here. It is very important to evaluate the sire summary to understand each value that is associated with your breed of interest.

Use of EPDs

Use of EPDs for Selection in Purebred Herds

Purebred producers need to consider EPDs in their breeding programs. Competitors are using EPDs and making genetic change in their beef herds. However, care needs to be exercised when making selection decisions. Type fads have caused some problems in the past when single traits have been emphasized. Similar, or worse, problems may arise if a single performance trait is emphasized. For example, if the members of one breed association began to emphasize yearling weight and ignored all other characteristics, several concerns might arise. Birth weight would be expected to increase, with the attendant calving difficulty. Mature size should also increase, perhaps to the point where the functionality of the cow herd would diminish. This could also lead to problems in reaching desirable quality grade at an acceptable weight. Each trait has a set of drawbacks if changes are carried to an extreme. The availability of EPDs would make such extremes easier to achieve if breeders chose to blindly emphasize a single trait.

A more balanced selection program is certainly desirable. Some producers recommend choosing herd sires that have a balanced yearling weight EPD, milk EPD and birth weight EPD. It also needs to be recognized that there are still many important traits that are not included in the sire summaries. Careful monitoring of reproductive performance, conception rates, calf mortality, regularity of calving and libido in bulls is critically important. Carcass characteristics may have increased importance in the near future; therefore, breeders are encouraged to obtain whatever carcass data is feasible and use it in making some selection decisions. Carcass EPDs should be available in several breeds soon, but more complete databases need to be established.

Most beef breed associations have EPDs. Purebred breeders should obtain EPDs on each member of their herd if their association provides the service. Although the accuracies are sometimes low on these EPDs, they should be used when choosing replacements and, where possible, when culling cows. Purebred producers are not only users of EPDs, but they also provide the data used in calculating EPDs. Producers are encouraged strongly to provide complete, accurate records on all calves born each year. Complete, accurate record keeping is the only way that useful EPDs can be calculated.

Use of EPDs for Selection in Commercial Herds

Commercial producers should be using bulls that are listed in a breed association's sire summary. What then should the commercial producer do about EPDs of their progeny? Many breed associations have a mechanism in place where individual purebred producers can obtain EPDs on each animal in their herd including the calves. Commercial producers should demand the information from their purebred breeding stock sources.

A commercial producer has a major responsibility of choosing the appropriate breed, or breeds, for his/her program. Once breeds are chosen, examination of what is needed in replacement breeding stock is in order. Some recommendations for commercial scenarios are shown in Table 3-8.

Each of these recommendations should be followed while at the same time considering the prevailing conditions. Rougher conditions probably dictate the need to avoid very high EPDs for growth or milk and even more to avoid high birth weights. Growth EPDs should be geared to the needs of the potential buyers. Also, traits for which there are no EPDs as yet can be important. Traits associated with reproduction certainly fall into this category. Commercial producers should demand that the seller's bulls should have passed a breeding soundness examination.

EPDs within a breed are directly comparable between herds. Therefore, if a commercial producer has more than one source of breeding stock, he/she can compare the genetic merit of the different sources.

Pedigree Estimated EPDs

Many sale catalogs will contain Expected Progeny Differences (EPDs) for the bulls offered for sale. Some bulls will appear in catalogs with limited or no EPD information. This may be particularly true for young bulls that have not had their performance information included in the breed genetic evaluation yet. Bull buyers may use a quick and easy procedure to compute "Pedigree EPD" values for young bulls with no EPDs.

Pedigree EPDs may be computed provided that you have access to EPDs on the animals in the pedigree of the young bull. By using the EPDs on animals in the young bull's pedigree, you are ready to compute Pedigree EPDs. Each calf receives a random

TABLE 3-8. Recommendations for EPDs for Various Commercial Scenarios

Use of Individual	Breed	Birth	Weaning	Yearling	Milk
Terminal sire on mature cows	Large carcass	Not too high	High	High	Not relevant
Bull to use with heifers	Small to medium size	Low	Moderate	Moderate	Consider, if keeping heifers
Sire replacement heifers	**Medium size maternal**	**Low to moderate**	**Moderate to high**	**Moderate to high**	**Varies**

sample half of the sire's genes and a random sample half of the dam's genes. The two halves combine to form the complete genetic makeup of the calf. Parents of the calf also receive their genetic makeup in the same way, with half of their genetic makeup contributed by each of their parents. By understanding this halving nature of inheritance, the EPDs on parents and grandparents in the pedigree of a young bull may be used to compute Pedigree EPDs.

Across-Breed EPDs

Since the inception of EPDs, it was easy to make bull comparisons within the same breed for selection decisions. Today that is still the case. However, the U.S. Meat Animal Research Center (MARC) in Clay Center, Nebraska, has made it possible to compare EPDs among different breeds. MARC has released a table of adjustment factors used to estimate across-breed expected progeny differences (AB-EPDs) for 18 breeds. Bulls of different breeds can be compared on the same EPD scale by adding the appropriate adjustment factor to the EPDs being evaluated.

Genetic Testing

Improvements in genomic technology have now made it possible to further enhance predictability of our current selection tools with the incorporation of genomic values into our genetic evaluations and thereby improving accuracy of EPD, particularly for younger animals. Hair follicles, blood card, semen or tissue notches are required for samples in the DNA test kits. DNA tests, however, do not replace the importance of collecting actual phenotypic data.

This technology can be used to help decide which bulls should be of value, as an early sorting stick of such. It will add value for commercial bull buyers because it can correct potential pedigree errors and increase the accuracy of EPDs on young animals. Use of EPDs will not change and remains the industry standard, but this technology is a means of mitigating risk by increasing the confidence of the EPD of young sires. Essentially animals will have the accuracy value that is typically associated with animals that have already had calves.

Genomic performance testing is currently available through Zoetis (GeneMax Advantage) and Neogen (Igenity and GeneSeek). Testing includes genetic markers for maternal, growth and carcass traits. Results are often represented as scores.

Genomic defect testing is now required by many breed associations for offspring of a sire or dam that is a known carrier of a genetic defect such as curly calf syndrome or calves born hairless.