

Using Decision Tree Analysis to Make Herd Management Decisions

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Introduction

Dairy producers and dairy consultants are continually faced with decisions. Making a decision between 2 alternatives, when both the costs and projected returns of each alternative are predictable with moderate to high accuracy, is fairly straightforward and can be performed with the aid of simple tools (e.g., partial budgets). More commonly, however, life is not so straightforward. Decision trees are formal quantitative tools that may be used to select the best course of action in situations where the decision is complex and outcomes are uncertain (Overton, 2004). Indeed, decision trees are particularly useful when there is uncertainty, since the probability of each potential outcome is factored into the analysis.

How to Construct a Decision Tree and Make a Decision Therefrom

Decision trees are constructed from left to right and begin with a square box called a root node or decision node. Lines are drawn from the box projecting toward the right, ending at a circle representing each of the decision alternatives that are available. Only one of these alternatives may be selected. Each circle may represent an outcome in itself or several possible outcomes that might result from that decision alternative may then be drawn, projecting still further to the right from each

circle. Values (in dollar amounts) are assigned to each outcome. Values may be positive or negative. A probability is then assigned to each potential outcome (when there is more than one) within a given decision alternative. Probabilities are sometimes available from the research literature. More often, probabilities must be estimated. This would seem to be a problem, but it is a problem that can be overcome (more on that later). Note that within a given decision alternative, the probabilities of the outcomes must sum to 1. Any costs associated with a given decision alternative are inserted and considered along that decision pathway. Finally, an “expected value” (again, in dollars- often this is instead referred to as “expected monetary value”) is calculated for each decision alternative by folding back the decision tree (doing calculations from right to left). Folding back to an expected value for each decision alternative involves subtracting any costs associated with that decision and then multiplying each outcome by its probability. The decision with the highest expected value is the recommended action to take. It is important to realize that the “expected value” is not the expected return (\$) if that alternative is chosen. The expected value is the average expected return (\$) of many iterations of the same set of circumstances.

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Examples

Figure 1 is an example of a simple decision tree constructed to evaluate the question of what to do with a cow with a left-displaced abomasum (LDA). The roll and toggle procedure is the preferred decision based upon the tree since the expected value of the roll and toggle (\$2195) is greater than that of surgery (\$2081) or shipping to beef (\$1503). Drilling down into the decision reveals that the cost of the surgery versus the cost of the roll and toggle is what makes the tree lean toward roll and toggle. Figure 2 is a re-evaluation of the same decision in an attempt to determine how much the success rates of the 2 procedures would need to change to shift the decision toward surgery. Readers of this monograph are encouraged to disagree with the assumptions contained in the examples and to draw their own trees to reach their own conclusions.

An example of a problem with the LDA example in Figure 1 is that it only values the profit from the current lactation and does not reward any profits from future lactations to the cow that survives and is kept. The LDA decision in Figure 1 was deliberately kept simple for purposes of illustration - a more complex analysis is certainly possible. Indeed, a more complex analysis reveals that surgical LDA correction is generally a better investment into a younger cow, due to the longer potential time available to recoup the cost of the intervention (Overton, 2004). However, surgery is still not necessarily better than roll and toggle.

Advantages of Decision Tree Analysis:

- Simple, easy and fast- can be done with paper and pencil.
- Decision trees offer an easy to understand visual representation of the decision.

- Can be applied to complex decisions involving many alternatives.
- Provide a more robust analysis of the decision, given that the likelihood of each outcome is taken into account.
- During construction of a decision tree, issues surrounding the decision that may have historically gone unrecognized may become apparent. Furthermore, issues that were previously thought to be rare and therefore not even considered in the decision process, may become recognized to be important enough to change the decision.

Disadvantages (Some With Rebuttal) of Decision Tree Analysis:

- The probabilities associated with outcomes are often unknown. However, this is only a potential disadvantage since it is easy to adjust the probabilities up or down and then see how likely or unlikely a given outcome would need to be to alter the decision. If a probability would need to get into the unrealistic range to change the decision, then the original decision should be reasonable.
- Failure to consider a potential outcome can invalidate the tree, and therefore, lead to a spurious decision.
- It is difficult to use decision trees when an outcome is a continuous variable – e.g., the expected effect on milk production of an input under consideration. This can be partially overcome by assigning several possible outcomes over a range, each with an associated probability. This can be even better overcome by utilizing either advanced mathematics or appropriate computer software.

- Constructing a decision tree for the first time often requires several attempts. This is not a bad thing, since as noted above, the process of construction is often instructive in itself. However, some clients may not have the curiosity or patience to endure through the process and thus become frustrated and ultimately lose confidence in the tool. Note that this can be overcome by preparing a tentative tree ahead of time.
- Decision trees are not appropriate when catastrophic failure (e.g., bankruptcy) is a potential outcome. For example, in the case of a single game of Russian roulette where you had to pay \$10 to play and would receive \$1,000,000 if you won, a decision tree would lead to the decision to play since there is only a 1 in 6 chance of failure. However, most of us would choose to not risk death, even if the odds were only 1 in 6.

Summary

Decision tree analysis is a simple yet powerful tool. Decision trees offer a robust method of analyzing decisions, given that the likelihood of each of potentially many outcomes is taken into account. Furthermore, the actual construction process of building a decision tree can help to elucidate issues surrounding the decision that might have gone overlooked or inadequately considered.

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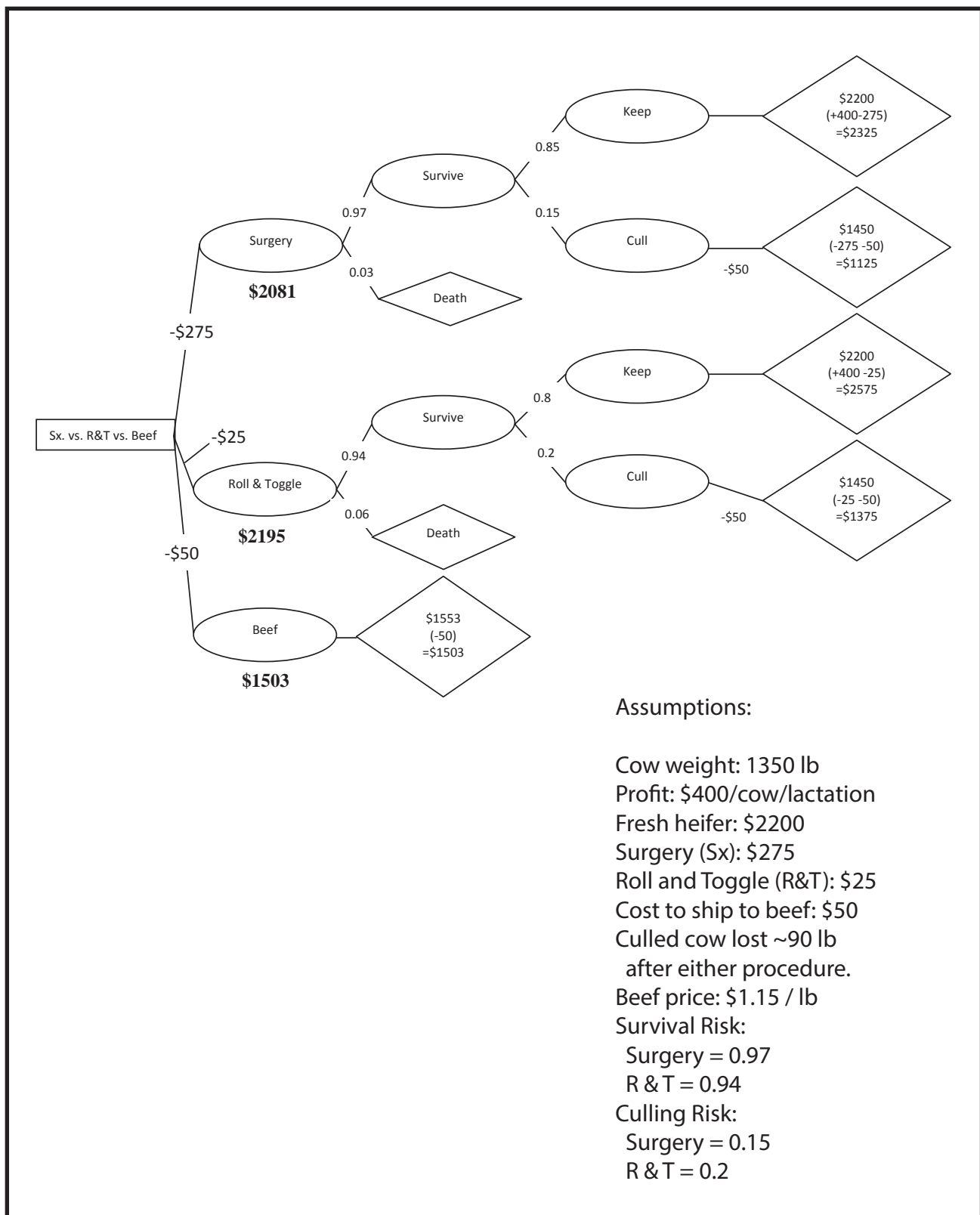


Figure 1. Decision due constructed to evaluate what to do with a cow with a left-displaced abomasum.

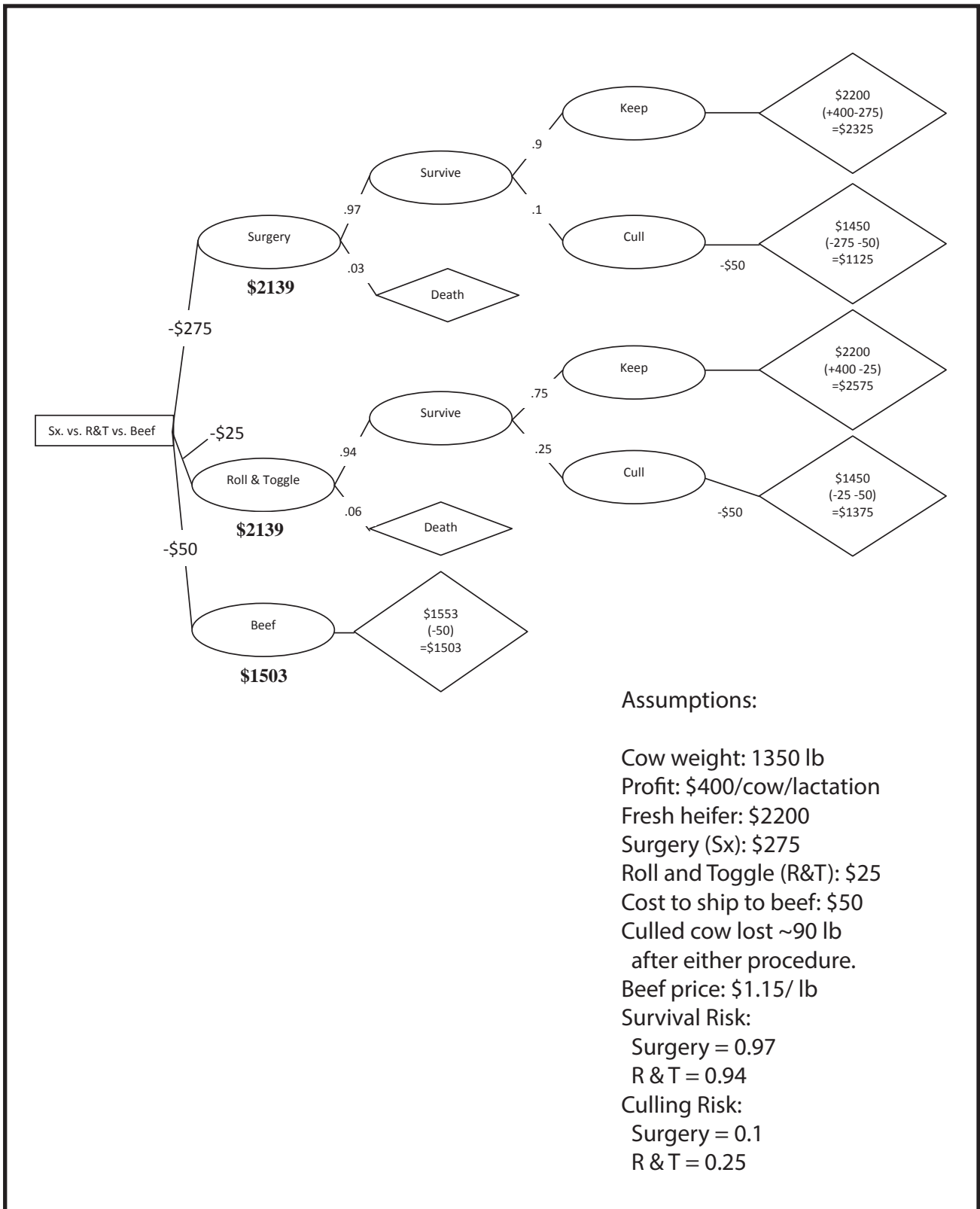


Figure 2. Decision tree contrasted to evaluate what to do with a cow with a left-displaced abomasun, using different assumptions than for Figure 1.

