Good morning, my name is Sophie Ivanovic, and I am part of the operations research team working on your project. I am excited to have this opportunity to work with you and am dedicated to providing the very best results and insights to help Teal Cow Dairy to expand their operations and overcome challenges of uncertainty.

Together with my team we have taken your communicated operational problems and created mathematical models to determine the optimal profit that can be achieved in each scenario.

I will now pass over to my colleague Ella.

Hi, my name is Ella Wang and I have taken the lead on mathematical formulations throughout this project. In the following report, we present Teal Cow Dairy’s optimal expected outcomes for profit across the year and expand on strategies that can be employed to ensure that such an outcome is reached.

If you have any questions about the report or our decision-making process, please don’t hesitate to reach out, we are here to help.

COMMUNICATION 11

In your initial communication, we were asked to determine a weekly feeding strategy over the course of a year which would provide Teal Cow Dairy with the greatest overall profit. CHANGE

This was a deterministic problem and thus, an explicit optimal feeding strategy could be devised. Key points for consideration in solving the problem and interpreting the results included the following:

* We consider only a sample data set of a herd of four cows.
* Each cow has a weekly minimum required amount of feed.
* Profit is earned from giving the herd extra units of feed, but there is a maximum of 10 extra units per cow per week. CHANGE

The optimal profit considering these constraints is $6946.80. CHANGE

This graph depicts the units of feed to give to the herd each week to earn the maximum profit. As you can see, in the first few weeks, only a small amount of feed is given to the herd so that the field can grow without being made barren. The amount of feed then remains fairly constant over the next 45 weeks with an average of 46 units per week and increases for the last 5 weeks to an average of 62 units. This uptick at the end of the year can be attributed to a diminished need to sustain the pasture for future weeks. CHANGE

Here, the optimal solution is broken down into extra feed and required feed for your reference. CHANGE

We have also included the exact data which you may use to enact the solution. CHANGE

COMMUNICATION 12

CHANGE

The second communication introduced a constraint to prevent the field from being barren at the end of the season. Specifically, for every unit of grass below 150 at the end of 52 weeks, there is a penalty of $5 .

In the short term, this can be expected to decrease overall profit since the penalty outweighs the profit of feeding another unit of grass to the herd. However, such a constraint increases the overall health of the field which will prove beneficial for profit in future years.

Taking this into account, the revised optimal profit is $6560.40. CHANGE

Graphically, we see similar trends to the previous solution. A small amount of feed should be given to the herd in the first two weeks, and then an average of 46 units of feed for the next 50 weeks. CHANGE

This graph depicts the breakdown into required feed and extra feed. Interestingly, there is a sharp decrease in feed given to the herd in week 46 despite no significant change in the required feed for this week. This may be a means to ensure that enough pasture is available at the end of the year to avoid large penalties. CHANGE

As before, we also include the optimal weekly feeding solution in numerical format for your reference. CHANGE

Overall, the main difference from the previous solution is a decrease in the amount of feed in the final weeks. This decrease results in a loss in profit of $386.40 which amounts to 92 units less of extra feed given to the herd. CHANGE

COMMUNICATION 13

CHANGE

In the third communication, changes in weather were incorporated into the problem. It was assumed, for simplicity, that the weather would be good 50% of the time, and poor the other 50%. With the revised model, the optimal profit is $6502.80. CHANGE

Now, the problem is no longer deterministic, so we are unable to provide exact units of weekly feed to achieve an optimal profit. We will instead proceed by describing an optimal strategy.

To do this, we determine the units of grass required at the beginning of each week such that the maximum units of extra feed – 10 units per cow in the herd – are given. This is considered an indicator of the optimal strategy since extra units are the source of profit for the dairy and would be maximized in an optimal solution. CHANGE

Our model suggests that to achieve a maximal profit, Teal Cow Dairy should aim to begin each week with the units of grass shown. CHANGE

The previous data is displayed in the top graph. Comparing it to the required weekly feed below, we note a similar upwards trend. CHANGE

In reality, due to constraints on growth, it would be infeasible for Teal Cow Dairy to have these exact units of grass available at the beginning of each week, but the strategy does serve as an indicator of thresholds of grass to strive towards to maximise profit. More realistically, this graph depicts the units of initial grass required each week to ensure over 30 units of grass are converted into milk. Such a strategy would achieve a profit of $6619.20 which is close to the optimal profit we calculated.

COMMUNICATION 14

The fourth communication introduces a new action that needs to be decided each week. CHANGE

Now, we can choose to dry off cows, meaning their lactation is stopped for the remainder of the season. This has two affects: the required weekly feed is reduced by three units for each dry cow but, dry cows cannot produce milk and so no profit can be gained from them. With this added variable, the optimal profit after a year becomes $6772.40. CHANGE

Again, we assume that the optimal strategy can be informed by the required initial units such that the maximum number of extra units of feed can be given. CHANGE

This graph depicts these required initial units of grass. As shown, in the optimal strategy, for the first 18 weeks it is not in Teal Cow Dairy’s interests to dry any cows. In these weeks, 40 extra units of grass can be given to the herd since the whole herd is lactating. Following this, the strategy suggests cows should be dried in weeks 19, 45, 48 and 49. As depicted, drying cows corresponds to generally lower initial units of grass since it reduces the maximum number of extra units that can be given. CHANGE

In the case that these requirements cannot be met, to ensure that at least 5 extra units of feed per lactating cow are given to the herd each week, the strategy is as shown. The general trend is similar to the previous strategy which reinforces that cows should be dried around weeks 19, 45, 48 and 49 to achieve an optimal profit.

COMMUNICATION 15

The final adjustment to the context of the problem is a consideration for the differences between the four members of the herd when determining the required units of feed each week. With this adjustment, the overall problem involves many constraints as shown. CHANGE

The final optimal profit considering all constraints is $6790.46. CHANGE

Again, we find the required initial units of grass such that the maximum number of extra units can be given. The model suggests that Rosie should be dried first in week 18, followed by Clover in week 45, Betty in week 48 and finally Lily in week 49. Overall, it is clear that most cows should be dried closer to the end of the year to ensure that profit can be maximised throughout the year and required feed is minimised at the end of the year when penalties are incurred. CHANGE

This graph depicts the required initial units of grass in this optimal strategy as well as displaying when cows should be dried. To achieve a maximal profit, Teal Cow Dairy should aim to follow this strategy as closely as possible. CHANGE

Thank you for your time and please reach out if you require any further clarification on any of the points raised.