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REDUCING THE RISK OF FEEDSTOCK SHORTAGES IN A BIOFUEL SUPPLY CHAIN

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ABSTRACT

Inventory is a critical component of every supply chain. Typical supply chain inventory management strategies can be applied to biofuel inventory; however, depending on the feedstock, one might should follow a completely different paradigm. For example, when using single stem poplar as feedstock in a biofuel supply chain, the typical inventory policies do not apply. If poplar inventory is stored in the field, the inventory will continue to grow, thus increasing its value. When disease and drought conditions are present; however, they can affect a portion of all the fields in the system regardless of their age. While there are some poplar genomes that are more resistant to disease and drought, they may lack the ideal growth curve. In this case study, we look at the tradeoffs around growth curves, drought and disease tolerance, and storing inventory in the field.

1. INTRODUCTION

This study focuses on a biofuel supply chain using single stem poplar as a feedstock. The model was set up to provide feedstock to a refinery requiring 2000 dry tons of biomass per day. The process starts at planting the field. The trees continue to grow annually until harvest. When harvested, the trees are transported to the refinery and the field is replanted.

The model is used to determine which poplar genomes to plant. While some poplar genomes are fast growing, they might not be tolerant to disease and drought. Other genomes might be tolerant to disease or drought, but they may grow at a slower rate. The decision is not just about selecting a single genome but determining the appropriate portion of various genomes in order to reduce the risk of a feedstock shortage while still providing low cost and high-quality feedstock.

Another purpose of the model is to determine how many fields the refinery requires. Since the trees can continue to grow in the field even after their ideal harvest age, designing the supply chain for excess feedstock could be a good strategy. The excess feedstock, the fields that has passed its ideal harvest age, could be sold on a secondary market.

Finally, the model is used for is to determine tree spacing in the field during planting. Spacing affects both growth tree growth and overall field yield. Planted trees too close together will begin to slow their growth as they mature because they are fighting for the same water, nutrients, and sunlight. However, the spacing effect is negligible when trees are young. If the supply chain feedstock forecast is low and the field might intend to be harvested at a relatively young age, then planting the tree with minimal spacing would be best. If the supply chain feedstock forecast seems to be high and the field might intend to be harvested past the ideal harvest age, then planning with maximum spacing would be best.

2. SIMULATION ARCHITECTURE

The model was developed in ExtendSim using the Discrete Rate architecture. The model takes advantage of ExtendSim's internal database for storing the model inputs and outputs, and more importantly, each field's current state throughout the simulation run.

The simulation input data included several poplar genome growth curves, which came from actual field data. The probability of mortality and probability of growth reduction events were estimated and used to weight the tradeoff between drought and disease tolerance and growth. Four region types were included in the study. They varied between low drought zones to very high drought zones. Each region type had probability of mortality events as well as growth-reduction events.

The simulation input data included various field parameters. The field parameters included the total number of fields, field size, and the number of trees per acre. The field parameters also included the tree genome planted in each specific field. The simulation input data included various harvest parameters, which included the age when the trees could be, should be, and must be harvested.

3. RESULTS

The results of the simulation capture the annual amount of unmet biomass demand at the refinery as well as the number of fields which were harvested past ideal harvest age. As an example, the chart in figure 1 shows these values across 100 years. This chart shows the fields too young to harvest (brown), the fields which could be harvested if needed (light green), the fields in the ideal harvest age (dark green), and the fields which have past the ideal harvest age (black marks). This chart illustrates how drought and mortality events make an impact on the supply chain not only in the year they occur, but they also have an even bigger impact on future years.

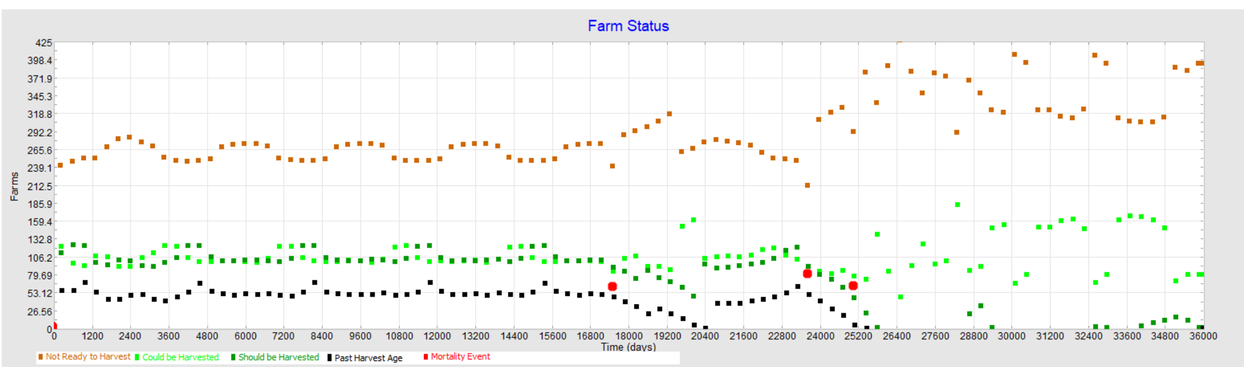

Figure 1: Farm status chart.

4. CONCLUSIONS

Feedstock inventory is critical for a biorefinery. When the biorefinery runs out of feedstock, it either must shut down until the next harvest season or pay a premium for buying and transporting feedstock from outside of their typical supply chain footprint. This study compares several approaches applied separately as well as in conjunction with each other in order to reduce the risk of feedstock shortages.