FORAGE HARVEST PROCESS TIME MOTION ANALYSIS AND OPTIMIZATION

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Introduction

Silage is a popular feedstock for dairy cattle. Corn production for silage has grown steadily in the past years, with more than 128 million tons produced in the United States in 2014, up from 116 million tons in 2012. Growers in the state of Wisconsin produced nearly 16 million tons of corn silage and over 9 million tons of haylage during 2014. However, making it requires a large input of time and energy. Commercial dairies often employ multiple self-propelled forage harvesters (SPFH) and many transport vehicles to harvest their crops. Managing this fleet of vehicles is often a logistical challenge, leaving significant opportunities for improvements in efficiency.

A study was conducted on a commercial dairy in Wisconsin which used two self-propelled forage harvesters, 10 straight trucks and 2 tractor-trailers. Machine movement was tracked during harvest with Global Positioning System (GPS) receivers and Controller Area Network (CAN) data loggers placed in each vehicle. GPS loggers for non-CAN equipped vehicles were developed with Arduino Uno microcontrollers utilizing EM-506 GPS receivers. The Arduino loggers were installed in the cab of each truck and powered by the vehicle battery, and GPS data were collected at a frequency of 1 Hz via storage on a micro-SD card. Vector CANcaseXL two-channel data loggers collected CAN and GPS signals on SPFH's. The Vector data loggers stored CAN signals, such as vehicle speed and cutterhead speed while simultaneously collecting GPS data at 1 Hz. These datasets were stored together as binary log files on the CANcaseXL SD card. Data from the Arduino and Vector data loggers were downloaded and copied once a week during harvest times. Hand-written notes were collected that recorded the time and order of trucks filled for verification of work status during data analysis. During the 2015 growing season, data were collected on these machines for 450 acres of rye (*Secale cereale*), 1600 acres of alfalfa (*Medicago sativa*), and over 2000 acres of corn (*Zea mays*).

GPS tracking allowed for vehicles paths to be recorded (Fig.1). CAN signals from the harvesters were used to define work status for each vehicle. Using these data, linear models were developed and fit to each harvest, and used to identify practices that reduced harvest efficiency. A top priority in this study was to identify the appropriate number of trucks to keep the harvester working, as it is the most expensive machine in the field to operate. More commonly, however, too many transport vehicles were used during harvest, and trucks often sat in the field waiting to be filled. It was important to determine the number of transport vehicles that did not reduce SPFH efficiency. By manipulating the models, the harvest process could be optimized to reduce machine down time, such as idle forage harvesters or trucks, and improve the efficiency of harvest.

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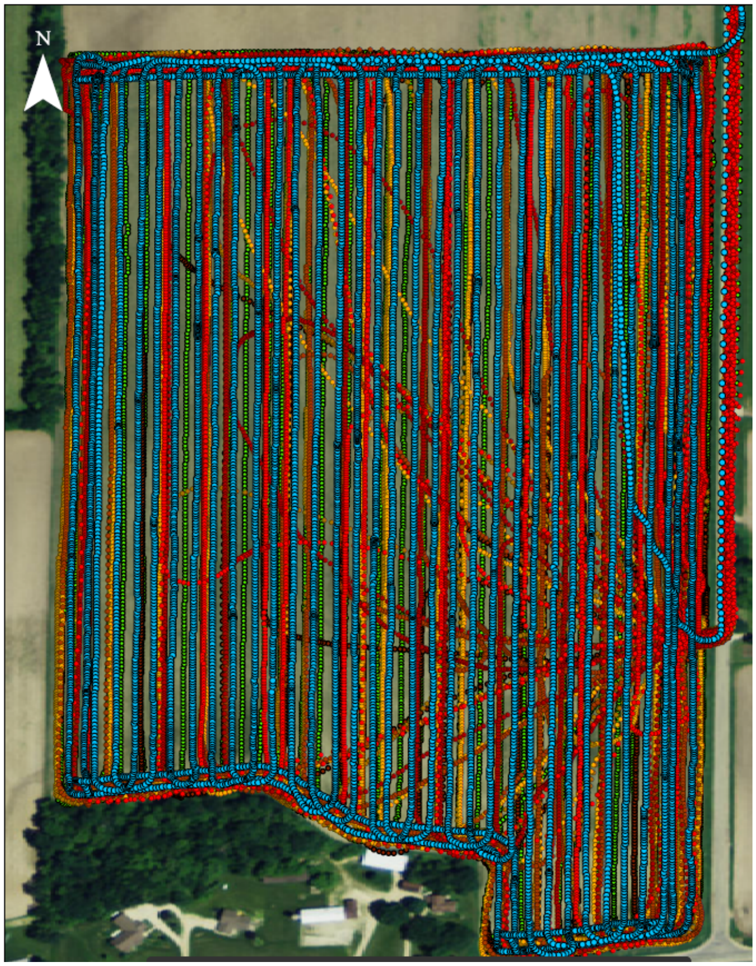

Figure 1. Global Positioning System (GPS) receiver locations of all vehicles involved in rye haylage harvest in May 2015 for one 60-acre field.