Optimizing the Use of a John Deere Bundling Unit in a Southern Logging System

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Abstract

Enormous amounts of untapped energy sources exist within the forestry realm. With the current energy crisis and with petroleum prices skyrocketing, all sources of alternative fuels need to be explored. John Deere’s Biomass Bundler unit is an effective machine for harvesting forest residues, which can be used as a source of fuel wood and/or a feedstock for biofuel and biobased product production. This project aims to explore an avenue that could supply a very promising source of readily available energy in Southeastern forested lands.

In order to fully utilize forest resources, all available material must be captured. Typical, southern harvesting operations consist of whole tree harvesting in which trees are felled, then skidded to a landing. Limbs and tops from the deck are usually either deposited over the landscape or piled in wind rows. The biomass bundler will serve to capture the otherwise non merchantable material and maximize the marketability of the entire tree. In order to reduce costs, maximize efficiency, and implement the bundler in a tree length harvesting operation, this project will test a prototype harvesting system. The objectives of this venture are to: a) adapt the John Deere 530B bundler unit to a motorized trailer; b) design the optimum deck configuration; c) conduct a productivity study of the bundler unit.
Introduction

There is 368 million dry tons of biomass available annually on a sustainable basis from forest-derived resources in the US (Perlack et al 2005). This represents a huge potential resource for energy production (Rummer et al 2004). With the current energy crisis and with petroleum prices skyrocketing, all sources of alternative fuels need to be explored. John Deere’s biomass bundler unit is an effective machine for harvesting forest residues, which can be used as a source of fuel wood and/or a feedstock for ethanol based fuel production. Although technologies and markets for such innovative practices have not yet matured, this project aims to explore a system that could supply a very promising source of readily available energy in Southeastern forested lands.

According to the United States Department of Energy’s Comprehensive Energy Plan, one of the key goals for the nation is to diversify America’s energy supply. The government aims to promote alternative and renewable sources of energy (Bodman 2005). The Energy Policy Act, part of the energy plan, sets goals of producing 250 million gallons of cellulosic ethanol by 2013, and one billion gallons by 2015 (Morris 2006). One of the most prevalent sources of cellulose for ethanol production are forest residues (Perez-Verdin 2008). Such ambitious national energy goals require a vast supply of renewable feedstocks.

In order to fully utilize forest resources, all available material must be captured. Typically, southern harvesting operations consist of whole tree harvesting in which trees are felled, and then skidded to a landing. Limbs and tops are removed from the tree and either deposited over the landscape or piled in wind rows. The biomass bundler will serve to capture this otherwise non-merchantable material and maximize the marketability of the entire tree. The bundler unit is utilized by feeding slash into a set of four compression feed rollers. Two compression arms then further compress the slash while sliding the bundle forward. A rotating twine magazine then fastens the bundles with bailing twine. At a predetermined length, the automated cutting
saw severs the compressed slash resulting in a slash bundle sometimes referred to as a compressed residue log (CRL) (Martin 2008).

The John Deere biomass bundler is commonly used in applications with cut-to-length harvesting systems that require it to travel within a stand. John Deere currently manufactures the 1490D which consists of a B380 biomass bundling unit mounted on a forwarder chassis. In order to reduce costs, maximize efficiency, and implement the bundler in a tree length harvesting operation, this project will test a prototype harvesting system. The objectives of this venture are to: a) adapt the John Deere B380 bundler unit to a motorized trailer; b) design the optimum deck configuration; c) conduct a productivity study of the bundler unit.

Auburn University’s School of Forestry and Wildlife Science will lead the research. Personnel from Auburn University’s Biosystems Engineering, John Deere, and the USDA Forest Service will aid in the cooperative effort. John Deere is providing a 437C knuckle-boom loader, a motorized trailer, a B380 bundling unit, and technical support to the project. The School of Forestry and Wildlife Science will provide testing sites for the study. Biosystems Engineering and the Forest Service will provide tools and equipment for the mounting of the bundling unit and any fabrication of parts.

Project Justification
Current forest harvesting practices in the southern United States are very proficient in harvesting timber; however, the harvest of forest residues are economically inefficient or nonexistent in most of the conventional harvesting configurations in the region. Most logging crews in the South that capture the forest residues do so using a drum chipper. Chipping forest biomass is effective; however, it requires a large amount of capital investment to an already economically stressed industry. In woods chipping operations require the purchase of a chipper as well as chip vans for transport.

Outputs of the two operations differ as well. Wood chip piles, shown in Figure 3, pose a moisture content issue. Although the top and outer portions of chip piles can be dried to much lower moisture contents, the insides of chip piles remain much more saturated. With many of the biomass consuming plants desiring low moisture contents, any low energy process to dry biomass could prove to be a huge asset to the industry. Figure 4 shows a bundle which have much more air space and air dry much better than chip piles. Within one month, bundles lost between 10 and 25% moisture content (Patterson 2008). According to an energy content equation, the loss of moisture content through evaporation in the bundles causes a 12-28% increase in energy content per unit volume (Karha 2006).

The configuration of the forwarder mounted slash bundler is an unreasonable application for use in the whole tree harvesting operations. With all of the stems being transported to the deck, the bundler is just as functional in a stationary configuration as it would be mounted on a prime mover. The John Deere B380 will be mounted on a trailer for transport and will be fed by the loader at the deck. The exclusion of the forwarder will result in far less overhead. Currently,
1490D slash bundling units list for around $600,000, and the proposed unit will be marketed for significantly less.

The proposed configuration, consisting of the bundler mounted on the motorized trailer, require less capital investment. The biomass bundling unit will require a very similar amount of initial investment as the chipper, but the bundles can be transported by customary log trailers. The use of ordinary log trailers will cut costs as well as create less deck crowding.

Although the absence of the chip vans will cause less deck crowding, optimal deck configuration with the bundling unit present is essential for logging crews to operate in the most efficient manner. The slash bundling must not interfere with the more lucrative product harvesting and processing, but it must be effective. The travel of the skidders must be unhindered because they are typically the limiting factor in harvesting operations. Merchandizing of the products also must not be impeded in order for the loader operator to maximize productivity.

Currently, loggers are purchasing the entire tree in a timber sale and only getting a return on the bole of the tree. Bundling enables the timber buyers to get the maximum return on their investment. At present, timber buyers can expect to see about $8-10 per ton for slash bundles.
As the market for such material begins to mature, prices and incentives for such innovative practices will be rewarded. The markets in the South are growing with bioenergy plants being built and will potentially come on line in the next 5 years (Example, Perdue 2007). These positive developments in the marketability of the bundles foreshadow the growing demand for forest residues.

**Approach**

**Mounting the Bundler**

In mounting the bundler on the motorized trailer, safety and functionality are of upmost concern. The bundler must be able to perform all of the designed swivel and tilt movements without risk of obstruction or instability. The slash must be able to enter and exit the bundling unit without impediment. Mounting connections are designed to withstand the large amount of torque and forces associated with the cantilever setup of the bundler and the position of the slash bundles.

The motor for the motorized trailer will be based on the flow demands of the John Deere bundling unit. The maximum flow demand for the unit’s functionality is 24 megapascals (Mpa)/3480psi (John 2008). Sizing of the engine is based on the horsepower demands of the hydraulic pump that powers the bundler. A 153 HP engine and a 75 gallon per minute variable
displacement pump will provide the power and flow rate needed for the bundler to perform. A thirty gallon reservoir to house the hydraulic oil will also be mounted on the trailer. The tank for the hydraulic oil will be equipped with a cooling unit in order to regulate the temperature of the oil in the Alabama summer heat.

**Design Optimum Deck Configuration**

Deck configuration is very important element in a logger’s productivity. “Good landings are important for a safe, efficient operation” (Stenzel 1985). If a deck is cramped and congested, the mobility of the workers and machines could be limited. The bundling operation cannot interfere with the travel of the skidder or the merchandizing or delimming of stems by the loader; however, the trailer mounted B380 must be close enough to the knuckle-boom loader that it can feed the bundler the forest residue. Our objective is to find the ideal deck configuration for the implementation of the bundling unit through testing different arrangements.

**Production Study**

Productivity will vary depending on the amount of material available on a site. John Deere reports 20-40 bundles per hour for the 1490D Slash Bundler dependent upon the availability and condition of slash (Martin 2008). In the forwarder mounted configuration, the unit would travel to retrieve slash. This study will test the trailer mounted B380 bundling unit’s productivity on a logging deck in which material will be available in very close proximity.

The study will include data collection on six study sites comprised mostly of southern pine species with a small hardwood element in central Alabama. Two of the sites will undergo first thinning timber stand improvement harvests. These sites will potentially contain varied amounts of pulpwood and a large amount of residue. Two sites will be second thinning sites in which most of the stand will be composed of pulpwood with some chip-n-saw. The last two sites will be clear-cut or final harvests. Saw timber, poles, and chip-n-saw will make up the majority of marketable wood classes present on the site. The latter four sites will have a significant amount
of residue from limbs, tops, and other non-merchantable stems that will be bundled at the deck. The survey of timber classes on each of the six sites will give researchers an idea of bundler production rates in the three harvesting operations. Bundler production will be assessed by recording the number of bundles and a tonnage production rate.

**Methods**

Preliminary stand data will be gathered before each harvest. The type of harvest, approximate stand age, and the species composition of each stand will be collected. Each harvesting operation will be monitored for two complete eight hour shifts. The Yellow Box® activity recorders will be mounted on the B380 to monitor use. The activity recorder is activated by vibrations of the engine and will simply return work and stop codes, as well as their respected time. The Yellow Box® will assist in productive and scheduled machine hour calculations for productivity analysis.

Student workers will be tasked with the collection of elemental time study data for the bundler operation. Video cameras will be used to gather all of the information and post processing will output most of the data. Production rates for the bundler will be calculated based on the time and output of the B380.

According to a May 2004 release from the Forest Service, ten foot bundles work well in transportation (Rummer 2004). For this study, the bundler software will be configured to output ten foot bundles. Elements for the bundler time study are feeding slash, cutting, and a delay element. The feeding of slash begins element begins as the slash from the knuckle-boom loader enters the feed rollers. The element ends when the chainsaw bar starts a downward motion. The cutting element begins when the saw begins its downward cutting motion and ends when the saw is in the upright position. Delay elements represent any delays the bundling process might encounter. Production rates will be reported in time/bundle, bundles/productive machine hour (PMH), bundles/scheduled machine hour (SMH), and tons/PMH. In order to increase efficiency and cut down on fuel costs, the bundling unit will only be operational when slash levels on the deck are high.
Literature Review

Published work on the bundling of forest residue is not very abundant. Because the configuration in this study is a prototype system, there is no prior literature on this particular machine. However, studies have been performed demonstrating the John Deere 1490D Slash Bundler’s operational abilities. The USDA Forest Service performed an operational performance analysis of the slash bundler in Idaho, Oregon, Montana, and California. The Forest Service’s main goal was to reduce fuel levels on the lands to thwart the threat of wildfires. Material bundled ranged from logging slash to small diameter trees. In Idaho City, Idaho, with large amounts of readily available slash, the bundler averaged twenty-four bundles per hour. Production levels ranged from five to twenty-four bundles per hour depending on the sites slash density and slash arrangement (Rummer 2004).

One study was performed in Arkansas by members of the Forest Products Society. The study consisted of four case studies performed on four different sites. Each of the sites underwent a different harvest regime. The first site consisted of a mature stand of loblolly pine clear cut harvested by conventional logging equipment. Logging residue was piled along the roadside to increase accessibility. The slash bundler produced 22.3 bundles per hour with an average cycle time of 2.69 minutes. Site 2 was a twenty-six year old stand of pine plantation undergoing a second thinning by the same harvesting system. Limbs and tops were piled at the deck and the slash bundler was able to produce more than 31 bundles per hour. Site 3, a stand of eleven year old loblolly pine plantation, produced 36.1 bundles per hour (Patterson 2008).

The fourth site in the study was a thinning operation in seventeen year old loblolly pine plantation. Cut-to-length harvesting equipment was utilized on the site which meant that the 1490D had to travel in-woods to gather material. The resulting 13.8 bundles per hour reflect the operational differences. The average weight of the bundles for sites one through four are 883, 916, 950, and 957 lbs (Patterson 2008).
John Deere published numbers in a presentation of a study done in France showing 2006 production numbers. Study conditions are unknown, but the France study reported eighteen to twenty-five bundles per hour was feasible with the 1490D. An aside was made that these production rates could be achieved with an experienced operator and appropriate site planning (Martin 2008).

**Hypothesis and Future Research**

Production of the John Deere B380 is largely dependent on the flow of slash. In southern logging operations, where slash is readily available at the deck, the stationary application of the unit is ideal. Thirty-five to forty bundles per productive machine hour for the proposed trailer mounted bundler is realistic in ideal stand conditions. The reduced cost and ease of transportation, for both the bundles and the machine, will make the bundler configuration a marketable commodity in the near future for whole tree harvesting systems.

After successfully completing this venture, research will continue on improving the bundler configuration. Instead of powering the B380 using a motorized trailer, the feasibility of a knuckle-boom loader powering the hydraulic flow demands of the bundler can be investigated. If the loader can fully satisfy the hydraulic flow demands of the bundler unit, research into mounting the bundler onto a knuckle-boom trailer will be explored.
Literature Cited


