The Effect of Pile Size on Moisture Content of Loblolly Pine while Field Drying

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Abstract

A 14-year old loblolly pine (*Pinus taeda*) plantation approximately 5 acres in size was cut during August 2013 with a tracked feller-buncher. A grapple skidder transported trees from one-half of the tract to a landing where they were piled whole-tree. Remaining trees were left whole-tree in skidder bundles (small piles) in the stand. All trees were left on-site and allowed to dry for approximately 70 days. After the drying period disks were cut from trees selected from the outer, middle, and bottom zones of each pile size for moisture content determination. Disks were cut from the butt, mid-stem, and top (approximately 2 inches) of each sample tree. A sub-sample of disks was taken at Dbh (Diameter at Breast Height). Moisture content (% wet-basis) averaged 23.8 percent for samples collected from trees located on the outside of the skidder bundles. Moisture content of samples taken from the middle and bottom sections of skidder bundles averaged 24.3 and 29.2 percent, respectively. Moisture content of samples taken from trees on the outside of the large pile averaged 28.6 percent, compared to 40.5 percent for trees located in the middle of the large pile and 48.9 percent for trees located at the bottom of the large pile. During the drying period rainfall totaled 4.77 inches. Temperature and relative humidity averaged 74.1°F and 71.7 percent, respectively.

Keywords: Whole-tree, heat value, Btu, oven-dry, water loss.

Introduction

With the recent growth in the number of pellet mills in the southeastern US, obtaining wood with reduced moisture content could be desirable. Field drying of trees is an effective method that can be used to reduce moisture content of green trees to lower levels, thus increasing the delivered BTU content. This method of drying wood by allowing transpiration to remove moisture from felled trees (Stokes et.al. 1987), often referred to as transpirational drying, is also known as "leaf seasoning", "biological drying", and "delayed bucking" (McMinn and Taras 1982). This drying enhances the BTU content, or net heating value, of the wood. The net heating value (NHV) is a function of oven-dry moisture content (MC), the higher heating value (HHV) and the energy loss required to remove moisture in the wood (Elliott 1980). This reduction in moisture content translates into having a product with an increased energy value before it leaves the woods, resulting in less water and more energy potential being transported.

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Field drying can be accomplished in several ways, including leaving whole trees in the stand in bundles, piling whole-tree at the landing in a large pile, or delimbing and piling at the landing. Pine trees left in bundles to dry have been shown to stabilize in weight reduction after approximately 50 days (Stokes et.al. 1987). Drying red oaks, sweetgum, and yellow-poplar for eight weeks during the summer had the most significant moisture loss during the first week after felling, where red oaks had the least reduction in moisture content and sweetgum and yellow-poplar had the highest moisture content reduction (McMinn 1986). Rogers (1981) evaluated drying loblolly pine, white oak, and sweetgum which were felled and allowed to dry for about three months during the winter season and moisture loss and net fuel values were determined for the heartwood and sapwood for each species.

Pellet manufacturing is a rapidly growing industry in the Southeast US. The US exported 1.5 million tons of wood pellets to the European Union in 2012 and some project this could increase to 15 to 20 million tons by 2020 (Shell 2013). Other wood energy markets, such as biorefineries, wood-fired electric plants, and wood-to-liquid fuel processes are often interested in procuring raw material with reduced moisture contents to increase energy value (Cutshall, et.al. 2011). Whole-tree loblolly pine were allowed to dry during the summer in south Alabama and resulted in a 55.3 percent reduction in moisture content, compared to 43.8 percent for delimbed trees during the summer and 29.4 percent for fall drying of whole-trees (Klepac, et.al. 2008).

Research has been conducted investigating moisture loss through transpirational drying for various species at different seasons. However, little or no research has been conducted to evaluate moisture loss in loblolly pine due to drying in different sized piles and zones within a pile. This paper reports research findings from drying whole-tree loblolly pine in scattered skidder bundles and in a large pile at a landing during late summer to early fall in south Alabama.

Methods

Operation

The study was conducted in a 14-year old loblolly pine plantation located in Monroe County, Alabama, approximately 5 acres in size. Felling was accomplished with a Tigercat[1] 845D tracked feller-buncher that utilized a shear-head. Trees were skidded with a Tigercat 630D grapple skidder, and a Prentice 210 C trailer mounted knuckleboom loader equipped with a pull-through delimber processed and loaded trees onto trailers after the drying period.

Trees were felled on August 20th and 21st, 2013. After felling was completed, bundles from one-half of the stand were skidded whole-tree to a landing where they were piled whole-tree by the loader for drying. Pile size at the landing was approximately 40 feet in length and 15 feet high.

[1] The use of trade or firm names in this publication is for reader information and does not imply endorsement of any product or service by the U.S. Department of Agriculture or other organizations represented here.

Bundles in the remaining half of the stand were left in place for drying. These bundles consisted of 1-3 accumulations of the feller-buncher. Trees were allowed to dry until the end of October 2013. After drying, trees were processed with a pull-thru delimber mounted on the loader and placed tree-length onto trailers.

Study Site

The site was planted on a 6-ft x 9-ft spacing. General soil type of the area was a Saffell-Lucy-Greenville, which is a well drained, gravelly, loamy, and clayey soil formed in marine and fluvial sediments (USDA Soil Conservation Service, 1983). Specific soil types included a SfD (Saffell very gravelly sandy loam – 8 to 15 percent slopes) and a BaC (Bama sandy loam, 5 to 10 percent slopes).

To determine stand density and mean tree size, a tenth-acre, fixed radius plot cruise was completed, which resulted in a 10 percent cruise. Within each plot, Dbh (Diameter at Breast Height) was measured on every plot tree and total height was measured on every tenth plot tree.

Climate data for the site during the drying period were obtained online from a station located in Evergreen, Alabama, approximately 16 miles away (Weather Underground, Inc. 2014). Climate data obtained included temperature, dew point, relative humidity, wind speed, and precipitation. Average daily temperature, humidity, and dew point were calculated by summing the maximum and minimum values and dividing by two times the number of days (Stokes et.al. 1987).

Drying and Data Collection

The drying period extended from August thru October and lasted 70 days for the large pile and 72 days for the skidder bundles (Figure 1). At the end of the drying period trees were selected from three zones to represent outer, middle, and bottom locations in the piles. Nine trees were selected at each zone from the large pile and three trees were selected at each zone from three skidder bundles. Processing and loading trees onto trucks began with the large pile on October 30th and samples from these trees were collected during that time. Samples from trees located in skidder bundles were collected on October 31st.

Figure 1. Large pile at landing and skidder bundle within the stand near Burnt Corn, AL.

Selected trees were placed by the skidder at a location near the landing where mensuration data were collected and disk samples were cut for moisture content determination. Diameters were measured at the butt, Dbh, mid-stem and top. Total length and length to a 2-inch top were also measured. For trees with broken tops, length to the break and top diameter were measured. For moisture content, disks were cut from the butt, Dbh, mid-stem, and a 2-inch top. Trees with tops broken below 2 inches were sampled just below the break. Each disk was placed in pre-weighed, labeled paper bags and weighed in the field the same day using a portable scale.

Disk samples were left in the paper bags and placed in drying ovens at 105°C until either a constant weight was obtained or the difference between the last weight measured and the previous weight was less than 0.2 percent after one hour or more of drying time.

Results

Study Site

The cruise summary revealed there were 438 TPA (trees per acre) in the 4-inch to 13-inch Dbh range and that the stand had a stocking level of 131 whole-tree green tons per acre (Clark and Saucier, 1990). Quadratic mean diameter was 7.4 inches with a mean total height of 51.2 feet. Approximately 74 percent of the standing trees were in 4-inch to 8-inch diameter classes.

Climatological data for the study period are summarized in Table 1 and include the period from the first day of felling (August 20th) to the last day of sample collection (October 31st). High and low values in the table reflect the average over the drying period, except for precipitation, which reflect the highest and lowest precipitation amount observed on a particular day.

Table 1. Climatological data for the drying period from the weather station in Evergreen, Alabama.

Variable	High	Average	Low	Total
Temperature (°F)	85.6	74.1	62.7	-
Humidity (%)	93.7	71.7	49.6	-
Dew Point (°F)	68.7	64.1	59.6	-
Wind speed (mph)	23.2	9.7	2.0	-
Precipitation (in)	1.51	0.07	0.00	4.77

The weather station in Evergreen measured a total of 4.77 inches of precipitation during the study period. No precipitation was observed during the last week of the drying period.

Drying and Data Collection

Sampled trees ranged in size from 3.6 to 10.5 inches Dbh and averaged 7.0 inches for the large pile and 7.3 inches for the skidder bundles. Lab results indicated overall moisture content for the large pile was 39.3 percent and 25.6 percent for the skidder bundles, a difference of 13.7 percent (Figure 2). In general, moisture content was higher at the bottom zone and driest at the outer zone. However, this trend did not hold true for skidder bundles where trees sampled in the middle zone on average had slightly lower moisture contents as compared to trees in the outer zone. This is most likely due to the small bundle sizes and the small difference between the middle and outer trees' exposure to the air.

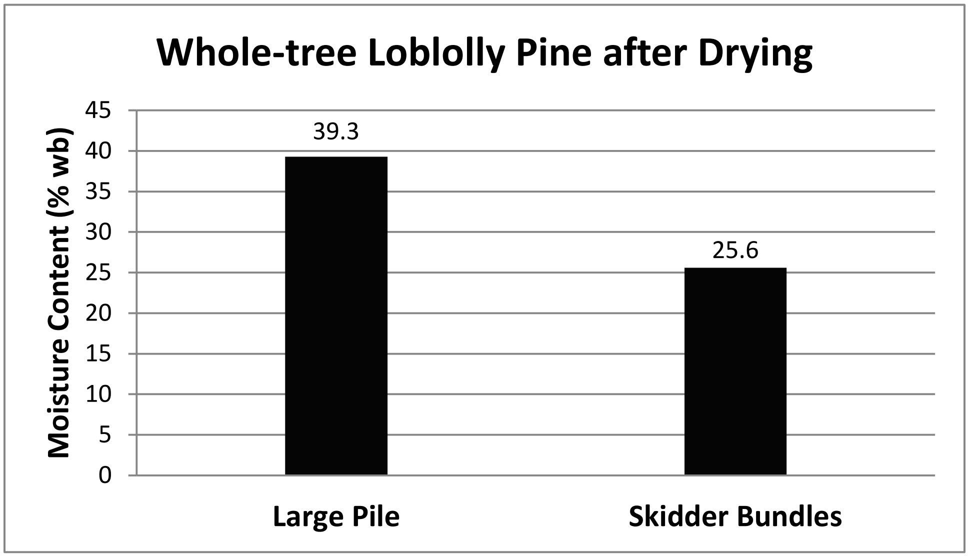

Figure 2. Comparison of moisture content between pile types.

Figure 3 displays comparisons of moisture content among zones within each pile type. For the large pile the largest difference in moisture content occurred between the bottom and outer zones, a difference of 20.3 percent. The difference between the middle and outer zones for the large pile was 11.9 percent followed by 8.4 percent between the bottom and middle zones. Differences in moisture content among zones for skidder bundles were much lower with the largest difference also occurring between the bottom and outer zones at 5.4 percent. Comparing the bottom and middle zones resulted in a difference of 4.9 percent, followed by a difference of only 0.5 percent between the middle and outer zones.

Comparing moisture contents between zones for each pile type revealed large differences for both the bottom and middle zones between the large pile and skidder bundles. Moisture contents at the bottom zone differed by 19.7 percent between the pile types and 16.2 percent for the middle zone. Moisture contents at the outer zone only differed by 4.8 percent between pile types.

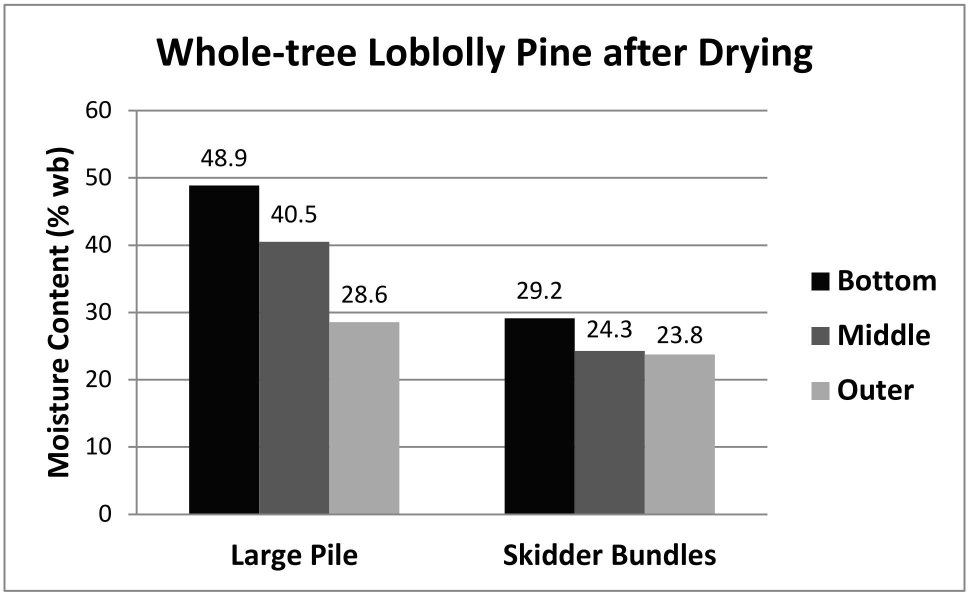

Figure 3. Comparison of moisture content among zones within each pile type.

Moisture content varied considerably at different locations along the stem. Descriptive statistics for moisture content by stem location for each pile type are summarized in Table 2. These statistics are overall for each pile type and do not account for differences due to zones. The highest variability occurred in the top samples of trees for both pile types as indicated by their standard deviations. Locations which were least variable were Dbh and mid-stem for the large pile and Butt and Dbh for the skidder bundles.

Table 2. Descriptive statistics for moisture content by location on tree for each pile type.

	Large Pile				Skidder Bundles			
Statistic	**Butt**	**Dbh**	**Mid**	**Top**	**Butt**	**Dbh**	**Mid**	**Top**
N	50	14	26	25	52	14	26	26
Mean	26.8	38.5	55.1	48.2	15.4	25.3	44.0	27.7
Std. Dev.	13.72	9.50	8.50	19.33	3.70	5.62	10.94	11.51
Min.	10.3	20.8	31.7	20.0	12.0	19.3	23.0	16.3
Max.	60.3	49.6	65.3	69.4	33.8	37.2	59.0	59.1

Using moisture contents on an ovendry basis, the NHV of wood samples was determined (Elliott 1980). To make this calculation, a HHV of 8600 Btu's per dry pound was used (Howard 1971). Results are summarized in Table 3 for both pile sizes. In order to display the magnitude of the percent increase of NHV from green, initial moisture content was determined from four sample trees cut at the beginning of the study which averaged 58.4 percent. Drying trees in the large pile at the landing resulted in a 73 percent increase in Btu content per pound of dry wood as compared to the initial Btu content before drying. Trees which were allowed to dry in skidder bundles resulted in a 112 percent increase in Btu content per dry pound. Final NHV for the skidder bundles was estimated to be 1338 Btu/lb higher than the large pile.

Table 3. Initial and final Net Heat Value between large pile and skidder bundles.

Pile type	Net Heat Value (Btu's/lb) Initial	Final	Percent Increase
Large pile	2877	4753	72.6
Skidder bundles	2877	6091	111.8

Discussion

In-woods drying of whole-trees appeared to be effective at reducing moisture content while field drying in south Alabama during late summer to early fall, especially for trees left in skidder bundles. In this study, skidder bundle size averaged 22.5 stems and ranged from 10 stems to a maximum of 43 stems. For the large pile, trees on the outside resulted in the largest reduction in moisture content. There are some advantages and disadvantages associated with each drying method. Analysis of samples for moisture content showed that trees left in skidder bundles dried more as compared to trees piled at the landing. For the large pile method, the feller-buncher and skidder are needed at initial felling. For the small pile method, the skidder is needed at the end of the drying period to skid bundles and it can also be used during loading to move away processed limbs and tops. However, the loader would be required on site twice for the large pile method; first to pile trees and then to load them onto trucks after the drying period.

Another factor to consider with hauling dry wood is that volume capacity on a regular size trailer is reached before weight capacity. Since wood markets pay on a per ton basis instead of a per Btu basis, underweight loads are still not desirable. To help alleviate this issue a large capacity, drop bottom log trailer that was developed with the intent of hauling drier wood was used in this study for hauling (Thompson et.al. 2012). Regular sized log trailers used for hauling wood from the study site were consistently underweight and averaged 22.41 tons per payload, while the larger capacity trailer averaged 26.04 tons per payload. Tare weights averaged 13.9 tons for the truck with the large capacity and 14.9 tons for the truck with the regular trailer. Therefore, it appeared the regular trailer reached its volume capacity first and averaged about two tons less per load as compared to the large capacity trailer.

An additional factor to consider is the economic impact of felling trees well before they are delivered. The cost of felling the trees is borne at the beginning of the drying period. If a large pile is created, the cost of the skidder and loader are also borne at that time. Logging contractors do not get paid until wood is delivered to a facility. Therefore, contractors would have to absorb the cost of pre-drying period operations well ahead of receiving income from the activity. The differential price paid for the lower moisture content must take into account the time value of money spent at the beginning of the drying period.

Conclusions

In this study we compared drying between large and small pile types. Small piles dried significantly more than the large pile. Trees in large piles do not dry evenly, while trees in smaller skidder bundles dry with less variability. Costs associated with pre-drying operations are lower with small bundles because less equipment is required for piling. A detailed statistical analysis needs to be completed in order to detect for significant differences in moisture content between pile types, among zones within a pile, and between zones between pile types after accounting for significant interactions which may exist.

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