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# Fuels characteristics of woods-run whole tree southern pine chips

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ABSTRACT

We designed a controlled experiment to assess the characteristics of operationally harvested wood chips across a variety of stand ages, species and soil types in the coastal plain of Georgia. A whole tree chipping crew harvested ten stands, five loblolly pine (*Pinus taeda*) and five slash pine (*Pinus. elliotti*), in the coastal plain of Georgia. Seven samples of chips were taken from each tract during harvesting from trees dispersed across the sites. Five samples were taken from whole-tree chips directly from the outfeed of the chipper, one sample represented chips made from trees pulled through a chain-flail delimber, and the final sample was from chips collected at the mill site during the off-loading of the truck. Bark represented 10–14% of the total sample weight, while foliage represented around 1.5% on average. Small but significant differences were present between the moisture (3%) and energy content (1%) of samples from the two species. Method of sample collection had a significant impact on the size distribution and composition of samples collected. Foliage levels in the sample had a substantial impact on the nutrient composition, while bark levels had a lesser impact.



## 1. Introduction

The rapid development of wood-based bioenergy markets in the southern United States has created a need for detailed understanding of the properties of the forest resources readily available for bioenergy production. A range of woody biomass feedstocks are currently delivered to bioenergy facilities; however, whole-tree chips are the major source currently delivered directly from the forest in the US South [1]. Whole-tree chipping has long been a component of American forest operations, originally producing furnish for pulping facilities and more recently being utilized for combustion fuel as the focus of pulp mills shifted to higher quality chips.

Many analyses on the properties of wood, bark, and foliage have been performed to determine the characteristics of both hardwood and softwood fuels. Howard [2] showed that pine needles typically produce more energy per pound than does pine bark while bark has slightly higher energy per pound than wood. Ince [3] compiled previous studies on the energy content of wood and bark for a number of common U.S. tree species, showing a wide variation in the measured energy contents between the species. Ash content of both bark and foliage are typically greater than wood [4,5].

While this information is extremely useful to understanding the energy characteristics of the resource, biomass delivered to consumption facilities can be a combination of all three components of the tree in addition to any possible

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contaminants that may be introduced during the harvesting process. Previous analyses of delivered biomass fuels have revealed wide variation in the composition of the fuels [5,14]. Extensive, field-based sampling is needed to assess the range of possible feedstock characteristics and successfully match feedstocks to potential markets. A careful analysis will ideally identify correlations between site, stand, and operating conditions and both desirable and undesirable feedstock properties.

This report details an extensive analysis of wood samples collected over five weeks from a whole-tree chipping crew operating in southeastern Georgia. The goal of this study was to examine the impact of site and stand variables on wood chip properties as they relate to bioenergy applications. This analysis will greatly improve the level of knowledge regarding the characteristics of woody biomass produced by in-woods chipping.

## 2. Methods

Ten tracts were selected from the Coastal Plain of Georgia. Tract acreage ranged from 5.5 to 42.2 acres, with ages ranging from 8 to 17 years. Five tracts were loblolly pine (*Pinus taeda*) plantations and five were slash pine (*P. elliotti*) plantations. On each tract, five plots were established covering the range of topography and soil types represented. Twenty-five trees were marked for removal in each plot. A different color of paint was used on each plot within a tract to differentiate them. A subset of painted trees was measured for diameter and height.

Each tract was thinned by a logging operation using one feller-buncher and two grapple skidders. Stems were fed into a Morbark 30/36 drum-style chipper. In each painted plot, all marked stems were felled and placed into a single bunch for extraction by the skidder. As each painted bunch was skidded to the landing and fed to the chipper, we sampled the chips using a 3 m section of 150 mm diameter PVC tube with a 90-degree elbow joint affixed to the end. The tube was placed near the outfeed of the chipper. At roughly 20 s intervals during the chipping of the painted trees, we placed the sampling tube into the stream of chips for 5–10 s to collect a sample of roughly 75 L. All painted trees were fed to the chipper with the limbs intact. This sample was thoroughly mixed, and three subsamples of approximately 2 kg each were placed in heavy-duty paper bags. Each bag was immediately placed on a scale and exact weight was recorded. Temperature and humidity at the time of sampling was recorded, as well as the duration of time between the felling of stems and their chipping.

In addition to the five painted tree samples per harvested tract, a 75 L sample was gathered from stems which had been delimbed by a chain-flail delimber. The delimbed samples were taken at random during the harvest from stems not within the painted plots. From each tract, a sample was also taken from one truck as it unloaded at the mill delivery point. The sample was taken as the truck offloaded using a live-bottom trailer. None of the chips in the truck samples had been delimbed. A 20 L bucket was used to catch chips as they fell from the back of the truck. Multiple samples were taken and mixed before subsampling. Delimbed and truck samples were treated identically to the painted tree samples, with three 2 kg bags pulled from the larger composite sample.

Two of the sample bags were placed in a 105 °C oven for 24 h drying. Oven-dry weight and moisture content were recorded. One of the sample bags was kept intact as a backup, while the other was processed in a Wiley mill through 1 mm screens and sent to the University of Georgia Soil, Plant and Water Analysis Lab for total mineral analysis as well as combustion in a bomb calorimeter to determine energy and ash content. The third sample bag was sorted in a chip classifier to determine the size distribution of the chips. Samples were sorted into seven size classifications: <3 mm, 3–5 mm, 5–7 mm, 7–16 mm, 16–45 mm, 45–63 mm and >63 mm. Foliage and bark content were also recorded with foliage removed from the full sample, and bark measured separately from wood down to 7 mm. Inner and outer bark were not differentiated. For the purposes of this report, chips sized 16–63 mm were deemed acceptable or “Accept”, >63 mm were oversized or “Overs”, 7–16 mm were considered undersized “Under”, 3–7 mm were considered “Fines”, and <3 mm “Dust”. It should be noted that the chipper and knives were not adjusted to maximize production of acceptable chips as defined by this study because the contractor was not obligated

**Table 1 – Chip properties compared between loblolly and slash pine, and between the three types of samples collected: from painted trees, from trees run through a chain-flail delimber, and samples taken from trucks at the mill.**

| Wood Chip characteristic | Loblolly ($n = 35$) | Slash ($n = 34$) | P - value | Painted trees ($n = 50$) | Delimbed samples ($n = 9$) | Truck samples ($n = 10$) | P-value |
|---|---|---|---|---|---|---|---|
| Moisture Content (% wet basis) | 52.3 | 50.8 | 0.004 | 51.2[a] | 53.0[b] | 52.1[ab] | 0.05 |
| Energy Content (MJ/kg) | 19.3 | 19.5 | 0.026 | 19.4 | 19.4 | 19.4 | 0.993 |
| Ash Content (%) | 0.57 | 0.49 | 0.221 | 0.50[a] | 0.44[a] | 0.76[b] | 0.002 |
| Accepts (% 63-16 mm) | 49.2 | 46.4 | 0.067 | 46.4[a] | 50.8[ab] | 51.5[b] | 0.05 |
| Foliage Content (% of wet weight) | 1.5 | 1.4 | 0.902 | 1.3[a] | 0.0[b] | 3.9[c] | 0.01 |
| Bark Content (% of wet weight) | 10.5 | 14.1 | 0.001 | 12.7[a] | 8.6[b] | 14.2[a] | 0.001 |
| Carbon (%) | 47.9 | 47.8 | 0.906 | 47.9 | 47.5 | 48.0 | 0.715 |
| Nitrogen (%) | 0.10 | 0.09 | 0.209 | 0.09[a] | 0.09[a] | 0.12[b] | 0.011 |
| Phosphorous (ppm) | 116.0 | 113.3 | 0.743 | 112.1 | 105.9 | 135.0 | 0.097 |
| Potassium (ppm) | 433.4 | 418.1 | 0.637 | 413.8 | 408.8 | 499.7 | 0.165 |
| Silicon (ppm) | 188.0 | 61.8 | 0.001 | 116.6 | 87.9 | 193.6 | 0.171 |

a,b,c Different letters within a row indicate a significant difference at listed significance level.