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Measuring Wood Moisture & Drying Time for Hardwood Tree Species

Why Measure Wood Moisture

The moisture content of wood burned in a wood stove directly impacts the efficiency and emissions. Wood burning efficiency is best when moisture is less than 20% and higher moisture levels reduce the ease and efficiency of burning. Moisture in wood reduces heat output because much of the energy is used to burn off the water in the wood. The burning process with wet wood produces smoke that contains soot which causes deposits in your stovepipe, increasing the chance of a chimney fire. Smoke is basically unburned wood and includes particulates which means higher emissions and air pollution.

Dry wood (20% moisture) burns hot and will provide a long burn which produces little smoke, which translates into low emissions. This will reduce conflicts with neighbors and communities where smoke from wood stoves has become a major problem.

How to Measure Wood Moisture

The efficiency and emissions of wood stoves is directly impacted by the moisture content of the firewood used. Conventional wisdom states that harvested wood should be split, stacked, covered and allowed to dry for about 6-12 months after it is cut, or until an internal moisture content of 20% is reached. Many factors impact drying time, including local climate, time of year wood is harvested, and the species.

Many firewood producers and users do not properly season their wood and may state it is seasoned after being split a few weeks or months. Unfortunately, many buyers do not know how to tell if wood is properly

Figure 1. Fresh cut oak wood on left and dried oak on right with wood splitting at ends and discoloration.

Figure 2. Moisture meters available for about $30. General Tools & Instruments on left and A.W Perkins moisture meter on right.

seasoned. One technique is to look at the splitting, called "checking" of the wood on the ends as an indicator of proper drying (Figure 1). The best way to be sure wood is properly dried is to use a moisture meter which is available from most home stores, woodstove retailers, or online. The two meters shown above (Figure 2) are about $30, cheaper if ordered online. These provide a direct digital readout. There are less expensive meters that use color-coded lights to indicate a range of moisture.

If you are buying firewood, ask when the wood was split. A research study by the University of Maryland found that live hickory trees cut into unsplit lengths (16"-18" long) and left uncovered still had over 30% moisture content after one year, while pieces that were split dried to about 20% moisture in 6 months. Consider the following:

- **Purchase a moisture meter.** To use properly, split a piece of wood and test the moisture content in the middle. The middle should be close to 20% moisture to be fully dry but if it is a bit higher, it will likely dry more completely if given a few months stacked and covered.
- **When buying wood from a supplier who claims the wood is seasoned, split a random piece of wood and take a moisture measurement BEFORE the truck is unloaded** (Figure 3). Once the wood is dropped it is hard to negotiate. If the wood is very wet (over 30%), it is not seasoned and you may refuse delivery or negotiate a lower price, realizing the wood will need additional months to dry.
- **Visit the firewood supplier site** and measure moisture on the wood before arranging a delivery.

Drying Time for Hardwood Tree Species

The research study undertaken by the University of Maryland determined the moisture drying pattern of four hardwood tree species in the Piedmont and Blue Ridge

Figure 4. Black locust wood drying on pallet.

Figure 3. Proper moisture measurement involves splitting a piece of wood and taking measurement in the middle of log. 20% is best. Higher readings will require more drying time.

region of Western Maryland, and time required to reach 20% moisture. The species in the study are black locust, hickory, black cherry, and hackberry.

Research Design

All trees used for the study were alive when felled and ranged from 12-18" diameter at 4.5' above the ground. Trees were felled in mid-April 2016, cut into 10-12' log lengths, cut into rounds about 16-18" long, then split into pieces similar in size and representative of those sold by firewood producers. The split firewood pieces of each species were stacked on separate pallets along a field edge that was in the shade until mid-morning (Figure 4). If the firewood had been in a location open to sun all day long, it may have reduced the drying time. The firewood was not covered so rain wet the samples.

An A.W. Perkins moisture meter was used to measure wood moisture. Initial measures were taken shortly after trees were processed and subsequent measures were taken monthly for a year. Three sample pieces of each species were selected at each measurement time. Each piece was split with a maul and three measurements taken on the exposed internal wood surface: 1) one inch from each end, referred to as "end moisture;" and 2) one in the middle of the log, referred to as "internal moisture." This allowed for a measure of average wood moisture, as well as separate measures of internal and end wood.

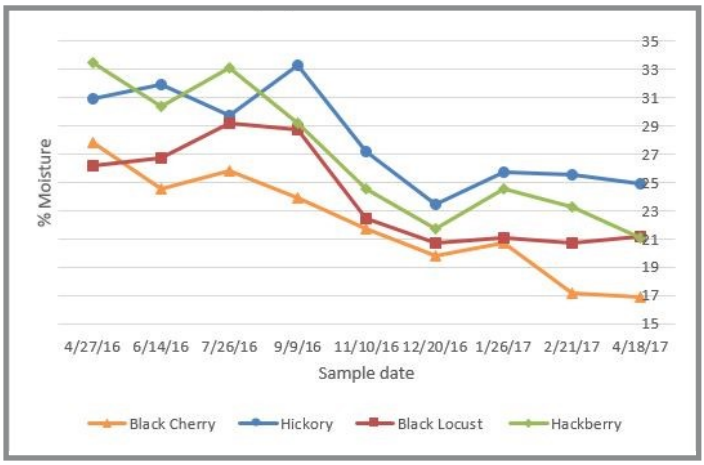

Figure 5. Firewood Drying Time for Four Tree Species. Average of Internal & Near-end Moisture

Results

Initial average moisture ranged from 25-33%. There was considerable variability in moisture content due to differences among tree species and size of the firewood pieces, but all species started to show a marked decrease in moisture between September and November (Figure 5), which is likely due to the cumulative impact of hot summer months and dry fall weather. By November, 6.5 months after harvest and processing, all species ranged in moisture from 20-26%. Black locust and black cherry were ready to burn at this time with sustained average moisture levels of 20-21%, which dropped well under 20% average moisture by December.

Hackberry and hickory dried at a slower rate and had 23-26% average moisture after 6.5 months but increased slightly the next month, most likely due to variability of firewood pieces selected.

Even after one year, hickory had averaged about 24% moisture content. Hickory is a dense, tight, and heavy wood so additional drying time is to be expected. The other species were acceptable for burning after about 7 months, well within the 6-9 month time suggested for drying firewood.

Internal Drying Time for Each Tree Species

Moisture measurements were taken on three sample of each species at each sample time. After each sample was split, the moisture was taken one-inch from each end, referred to as "end moisture," and in the middle of the log, referred to as "internal moisture."

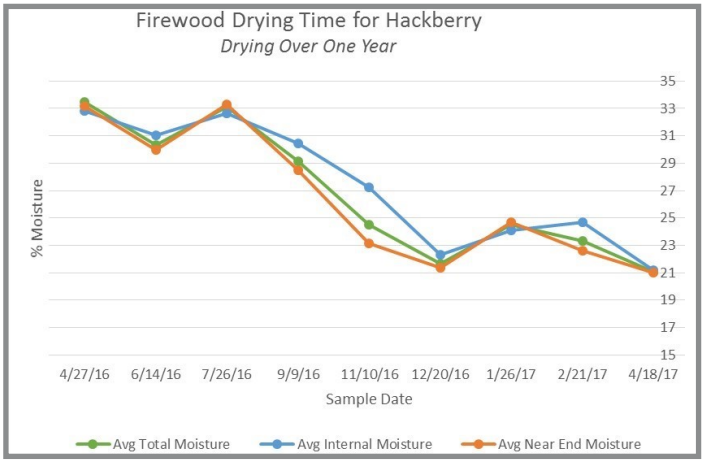

Figure 6. Hackberry: In general, hackberry dried in a very consistent fashion with few differences between internal

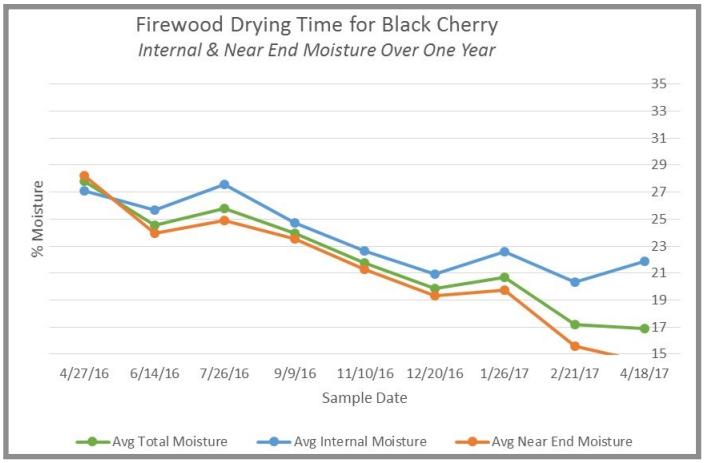

Figure 7. Black Cherry: Black cherry had little difference between internal and end moisture for most of the study. However, starting in January (9 months) the internal moisture appeared to level off while the end moisture continued to decline.

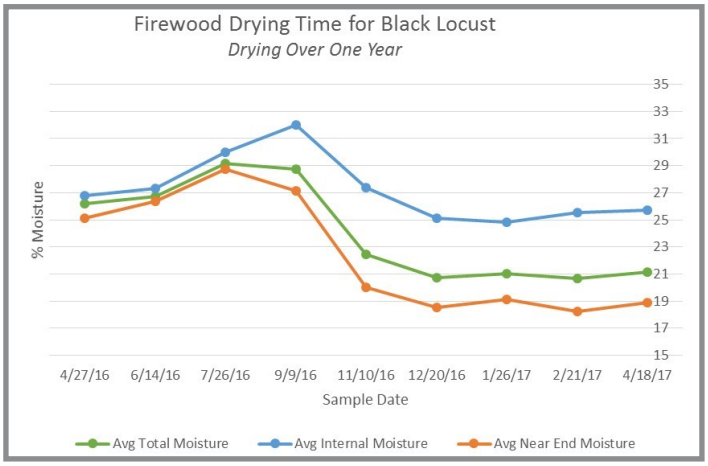

Figure 8. Black locust: The average moisture and end moisture of black locust was at acceptable levels by the end of the study, but the internal moisture was still high (~26%), indicating that more drying time was necessary to fully dry the firewood.

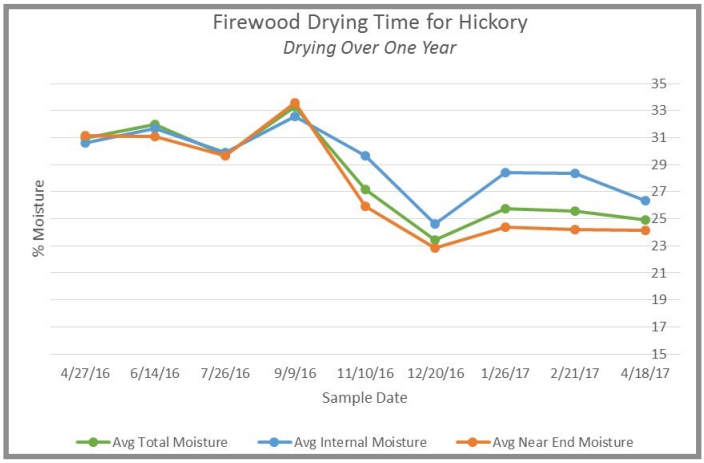

Figure 9. Hickory: The difference between internal and end moisture for hickory was negligible for the first 4.5 months (until 9/9/16) but started to expand afterward as the outer areas dried. It takes much longer for the internal area of a piece of firewood to be impacted by the drying process. After one year, the difference in moisture between the end and middle of the wood started to close, but the moisture levels were still well-above what is recognized as seasoned wood (20%). More months of drying would be needed.

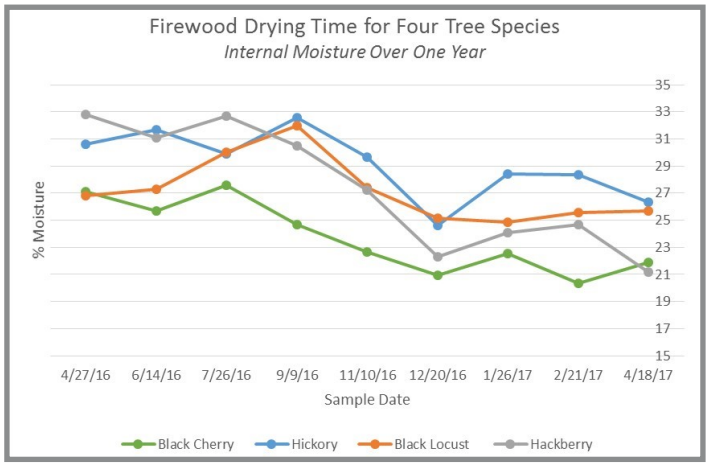

Figure 10. Internal Moisture: The graphing of internal moisture levels for each species shows the disparity between the species. Black cherry and hackberry had the lowest levels while black locust and hickory still have unacceptable internal moisture levels after one year.

Conclusions

The recommended drying time to produce well-seasoned firewood (20% moisture) is dependent on the species, size of the wood pieces and if they are split. Also, the actual time to dry may depend on your location, with longer drying required in more northern states or states with high humidity. While black cherry and hackberry cut at the wettest time of year may be well–seasoned after 6-7 months, denser woods such as black locust and hickory require longer periods of time, even if they are covered. Unfortunately, oak was not available for this study but its drying characteristics would likely be similar to that of hickory or black locust.

The more surface area exposed, the faster a piece of wood will dry. Small and short sticks of wood dry faster, those having more exposed surface and less interior. This is why firewood that is not split and left in rounds, will not dry appreciably until split. The outer layers of wood dry first and moisture is subsequently drawn out of the wood from the internal layers. This wicking process is hastened by shorter pieces of firewood. Also, the denser the wood, the slower the wicking process.

A Word about Woodsheds

There is no question that keeping your wood in a woodshed aids drying and makes storing and accessing firewood easier. Woodsheds come in all styles from the Cadillac to the Yugo. There are plans for building a $215 shed for a cord of wood, but you may have access to old roof metal, an old shed, or other resources. Use what is available! Covering with a tarp might help, but there is nothing like good air circulation inside a covered woodshed! See the resources below for plans and ideas.

The only way to tell if a load of firewood is well-seasoned is to measure the internal moisture in the middle of a freshly split piece of firewood. A moisture meter is essential to tell for sure the moisture content of your wood.

The benefits of well-seasoned wood include maximizing the heat (or Btu's) from the wood you cut or purchase. Wood with higher moisture levels will not burn as well and you lose much of the heating value, since it must use the heat generated to evaporate the moisture. This leaves less to heat your home. Properly seasoning your wood saves you money and/or reduces the time needed to cut more wood. Another advantage to seasoning your wood is that it minimizes the emissions from your stove. Wood smoke is bad for you and your family's health and can make for poor relationships with neighbors.

Drying times measured in this study may be reduced by doing the following practices:

- Cut trees in the late summer, fall or winter when above ground sap content is reduced. Trees in this study were cut in April when spring sap flow was maximized, and wood moisture was at its maximum.
- Build a woodshed, or at least cover the top of the wood pile so that air flow is maximized but rainfall does not soak the pile and retard drying.
- Elevate your wood off the ground or have a layer of plastic under the pile to stop moisture entering the wood from the ground. The wood in this study was left uncovered.
- Locate wood pile in a location that receives full sunlight all day. A more exposed location may have better circulation in addition to the additional solar energy.
- Ideally cut wood at least one full year before you intend to use it. Stack and store the wood as recommended above.

Figure 11. Photo on right is $215 wood shed based on EPA plans. Reference provided in woodshed resources

Woodshed and other Resources:

- Woodshed Resources
  - Plans Environmental Protection Agency (EPA) for $215 woodshed - https://www.epa.gov/sites/production/files/documents/woodsheddiagram.pdf
  - Many creative ideas for different wood storage applications - https://www.pinterest.com/explore/wood-storage
- Alliance for Green Heat (www.forgreenheat.org) – This national non-profit works to advance cleaner and more efficient residential heating technology, particularly for low- and middle-income families. They offer a free newsletter and other useful resources for homeowners.

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