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# TRANSPIRATIONAL DRYING of PIEDMONT HARDWOODS

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# ABOUT THE AUTHOR

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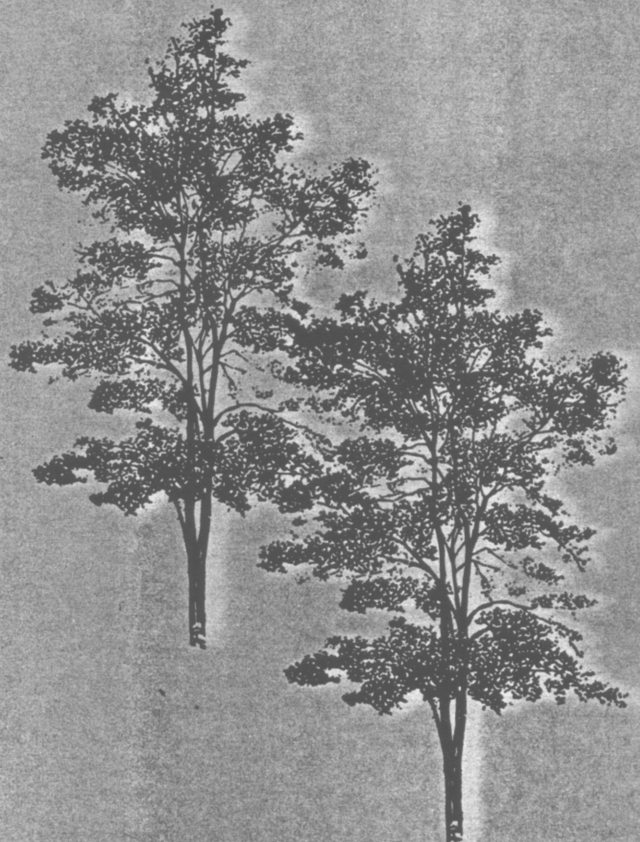

# TRANSPIRATIONAL DRYING OF PIEDMONT HARDWOODS

## INTRODUCTION

Moisture content can be one of the most critical factors limiting the use of wood for energy (2,10). The technique covered here is one of the most promising ways of drying wood quickly and economically. Transpirational drying consists of felling while the tree is in full foliage and leaving the entire bole and crown intact to allow moisture loss via natural transpiration mechanisms. The technique is also known as "sour-felling," "leaf seasoning," "leaf felling," "biological drying," and "delayed bucking." It has not been employed to any extent in the United States, but exploratory research indicates potential for various geographic areas and species (3, 8, 9, 11, 12). The effectiveness of the technique depends on species and drying conditions (8, 11,) and the potential benefits are not limited to fuel value per se. In one study, drying of material in the woods reduced forwarding costs (1), and it should also reduce road transportation costs. This paper presents preliminary results from a study in which we are developing predictions of moisture losses for whole trees and tree components.

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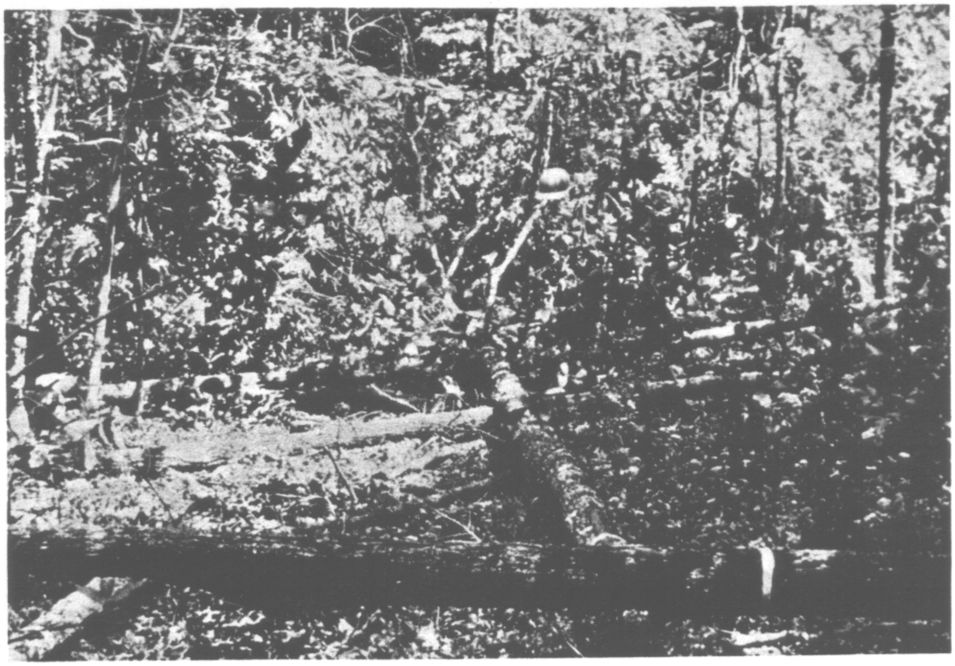

*Figure 1.--Trees felled and left to lie intact at the stump.*

## METHODS

The study was carried out in the Upper Piedmont of Georgia about 40 air miles NNE of Atlanta on land managed by the Georgia Forestry Commission. Study species were red oaks *(Quercus* spp.), sweetgum *(Liquidambar styraciflua* L.), and yellow-poplar *(Liriodendron tulipifera* L.). The red oak group was represented primarily by southern red oak *(Q. falcata* Michx.) with some scarlet oak *(Q. coccinea* Muenchh.) and black oak *(Q. velutina* Lam.). Trees ranging from 5 to 12 inches d.b.h. were felled in late July and left to lie at the stump (Figure 1). Then, a number of trees were destructively sampled weekly for up to 8 weeks (Figure 2). The samples covered in this presentation were disks (wood only) taken to represent stemwood. As disks were cut in the field they were placed in polyethylene bags, then returned to the laboratory for processing. In the laboratory disks were weighed, dried to constant weight of 103°C, and reweighed as a basis for moisture content calculations. Recoverable heat energy was estimated according to the procedure given by Ince (5). The following assumptions were made for the calculations:

- Higher heating value of 8,000 Btu./lb. for all species
- Ambient air and fuel temperature of 70°F
- Stack gas temperature of 500°
- Excess air of 40 percent
- Conventional heat losses of 4 percent

The derived recoverable heat energy is the energy remaining after the escape of heat in stack gasses and other heat losses. It is assumed that this portion of the higher heating value would be contained in some useful output, such as process steam.

*Figure 2.--Disks were removed from a sub set of trees at each sampling date.*

## RESULTS AND DISCUSSION

Transpirational drying for 3 weeks reduced moisture content from about 76 to 67 percent in red oaks, 120 to 62 percent in sweetgum, and 100 to 56 percent in yellow-poplar on an oven dry basis. Average wood moisture by drying time is presented in Table 1. Initial moisture contents were similar to those reported by Karchesy and Koch (6). Both the lower initial moisture content and lower moisture loss in red oaks can be attributed to the proportionally smaller area of active vascular tissue -- the outer one or two annual rings in ring-porous species (7). By contrast the two diffuse-porous species in which several outer rings contain active conductive tissue both lost substantially more moisture. These losses were much greater than have been reported from tree-length slash pine logs (4), and conifers are similar to diffuse-porous species in water conduction (7). Samples were collected over a full 8-week period to determine if slow translocation and evapotranspiration would continue, but none was apparent from the data. Drying was most rapid for all species during the first week, and there was no indication that significant moisture reductions could be achieved after the third week.

Table 2 presents estimates of recoverable heat energy associated with selected stages of transpirational drying. Two different bases were used for energy calculations, because each is legitimate and meaningful for a specific purpose or user. The first column was calculated on an oven dry basis or for a constant quantity of wood. A quantity of green red oak that includes 1 ton of actual wood will have an additional 0.76 tons of water contained in it. After drying a week, that same ton of wood will contain 0.65 tons of water. The increase in recoverable energy represents potential gain per chip, stick, tract, or a pile of given dimensions. For instance, transpirational drying of red oak could yield a given amount of recoverable energy on about 3 percent less acreage than green wood or 3 percent more recoverable energy from a given tract. Potential gains are 3, 14, and 11 percent for red oaks, sweetgum, and yellow-poplar, respectively. These figures represent the potential for reducing impacts on the primary resource via transpirational drying.

Table 1.--Average wood moisture content (oven dry basis) for stemwood of three Piedmont hardwood species or species groups by duration of transpirational drying (standard deviations in parentheses)

| Drying time | Species | | |
|---|---|---|---|
| | Red oaks | Sweetgum | Yellow-poplar |
| | *Percent* | | |
| 0 | 76 (2) | 119 (10) | 100 (13) |
| 1 | 64 (6) | 80 (17) | 63 (7) |
| 2 | 66 (5) | 73 (9) | 58 (10) |
| 3 | 67 (5) | 62 (6) | 56 (3) |
| 4 | 66 (5) | 65 (6) | 56 (10) |
| 5 | 62 (4) | 66 (13) | - |
| 6 | 67 (6) | 64 (4) | - |
| 7 | 66 (6) | - | - |
| 8 | 66 (5) | - | - |

Table 2.--Wood moisture content and recoverable heat energy for species or species group and duration of transpirational drying

| Species | Drying time | Moisture content (base) | | Recoverable heat energy | |
|---|---|---|---|---|---|
| | | Oven dry | "Wet" fuel | Per ton wood | Per ton fuel |
| | *Weeks* | *Percent* | | *Million Btu's* | |
| Red oaks | 0 | 76 | 43 | 10.338 | 5.874 |
| | 1 | 65 | 39 | 10.656 | 6.460 |
| Sweetgum | 0 | 119 | 54 | 9.330 | 4.260 |
| | 1 | 80 | 44 | 10.306 | 5.726 |
| | 3 | 64 | 39 | 10.594 | 6.460 |
| Yellow-poplar | 0 | 100 | 50 | 9.692 | 4.846 |
| | 1 | 63 | 39 | 10.530 | 6.460 |
| | 3 | 56 | 36 | 10.760 | 6.898 |

The second recoverable energy column was calculated on a wet weight basis, which is the accepted standard in combustion engineering. On this basis a ton of green red oak fuel will contain 0.43 tons of water and a ton of material that has been dried for a week will contain 0.39 tons of water. The wet fuel base shows more dramatic gains because -- unlike the above example, where the amount of actual wood is held constant -- as the moisture content decreases the amount of wood per unit weight increases. The increases in recoverable energy for this column represent potential gains in boiler output, transportation, or any activity for which gross weight of wood and water is the applicable standard. For example, transpirational drying would increase recoverable energy per ton-mile of trucking by 10, 52, and 42 percent for red oaks, sweetgum and yellow-poplar, respectively.

One final point should not be overlooked. Uniformity and predictability minimize operational problems and costs in almost any production situation. In addition to an overall average increase, transpirational drying reduced the variability in recoverable energy among species. On an ovendry basis the spread was reduced from an initial 11 percent to 2 percent. For wet fuel the reduction was from about 38 to about 7 percent. This means that -- whatever activity is being considered -- transpirational drying can to a substantial degree relieve a decision-maker from the need to be concerned with species or species mix.

## CONCLUSIONS

- **These preliminary results indicate that transpirational drying can produce substantial gains in recoverable heat energy for diffuse-porous species and more modest gains for ring-porous species.**
- **The most rapid drying occurs during the first week.**
- **Significant drying does not occur after about 3 weeks.**
- **Because diffuse-porous species with high initial moisture contents lose more water than ring-porous species with low initial moisture contents, the final moisture contents vary less among species than initial moisture contents.**

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