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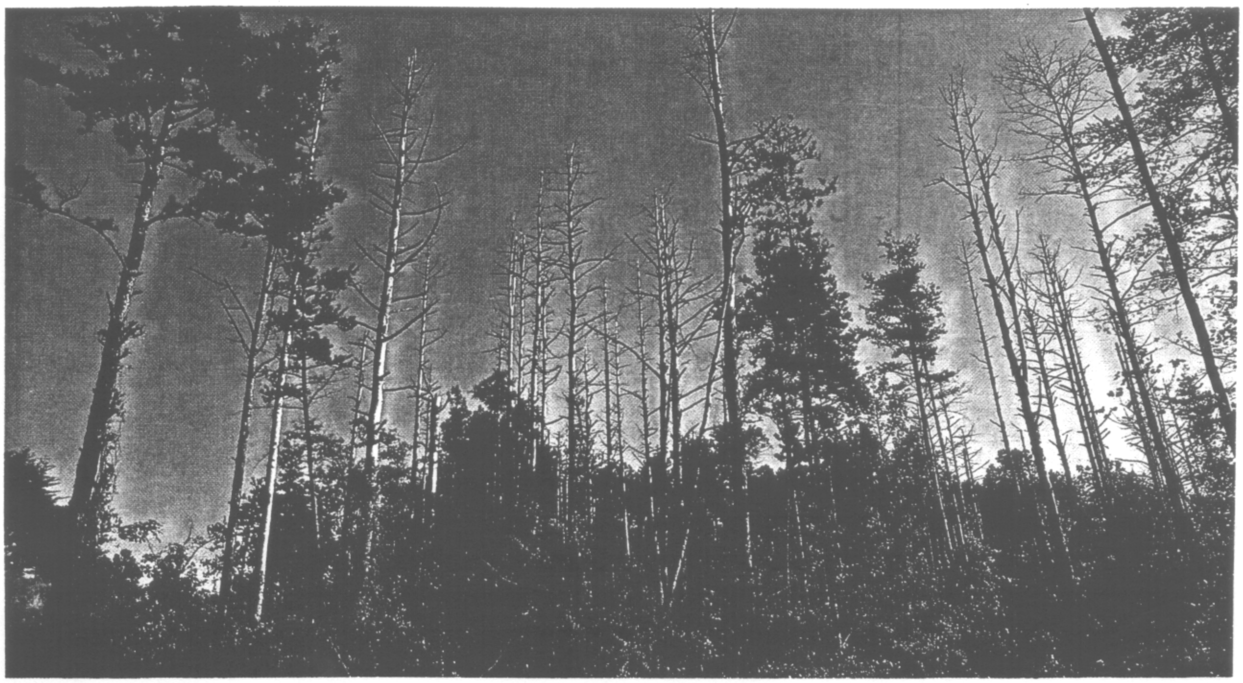


CREOSOTE PRODUCTION FROM BEETLE INFESTED TIMBER

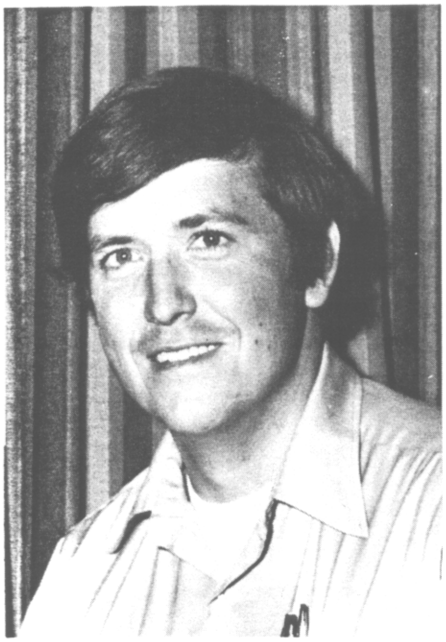
BY

J. FRED ALLEN AND TIMOTHY T. MAXWELL

RESEARCH DIVISION

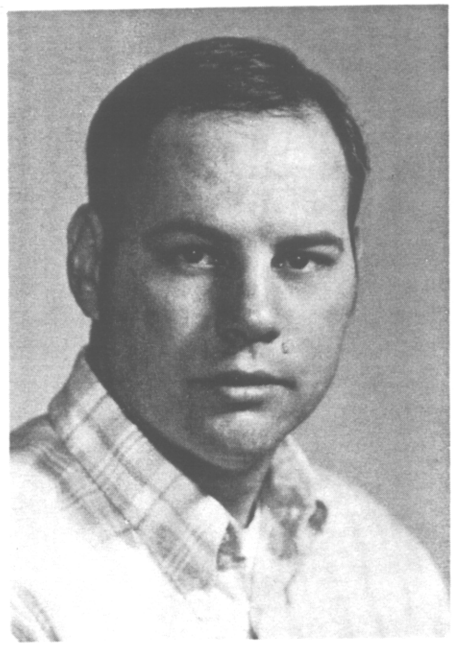
GEORGIA FORESTRY COMMISSION

AUTHORS



FRED ALLEN

J. Fred Allen is Wood Energy Specialist with the Georgia Forestry Commission, Research Department. He received his B.S.F. degree from the University of Georgia, School of Forest Resources, in 1970.



TIMOTHY T. MAXWELL

Timothy T. Maxwell is an Assistant Professor at Auburn University, School of Engineering. He received his BME and MS Degree in Mechanical Engineering from Auburn University and his Ph.D in Mechanical Engineering from the University of London in England.

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ABSTRACT

Tests were run to determine the amount of creosote accumulation produced by burning timber killed by Southern Pine Beetles in airtight wood burning stoves. Four stove and chimney assemblies were set up and burned for approximately one month. The creosote accumulation was measured by weighing the chimney components before and after the tests.

In addition to beetle-killed pine, green pine, green hardwood, and seasoned hardwood were also considered in the study; one was burned in each of the four stoves. The results showed that all of the woods produced significant levels of creosote with the stoves set at low air inlet rates. The beetle-killed pine produced the most creosote, while the green pine produced the least. The seasoned hardwood produced more creosote than did the green hardwood.

INTRODUCTION

Creosote is a common problem to wood burners. Creosote is a sticky, tar-like substance that accumulates in the chimneys and flues of wood burning appliances, especially "airtight" stoves and heaters. Incomplete combustion of the wood, a problem typical of airtight wood burning stoves, allows combustible compounds to escape from the combustion chamber of the stove. These combustible materials (vapors, liquid droplets, or solid particles) condense and stick to the chimney and flue surfaces which are relatively cooler than the combustion products. The resulting deposits are commonly called creosote.

Creosote deposits can in the worse cases actually block off the flue of an appliance. This would render the appliance unusable until the flue is cleaned. However, of greater danger is the possibility of the creosote igniting and burning inside the flue or chimney. When a creosote fire (the burning of the creosote inside the chimney) does occur, the temperatures attained in the chimney will be higher than during normal operation of the appliance. These excessive temperatures may damage the chimney and overheat nearby combustible structures. The end result would be a home fire.

The production and accumulation of creosote in the chimney of a wood burning appliance is a safety problem. If the creosote problem is to be alleviated, the mechanisms of creosote production and accumulation must be better understood. Obviously a more complete combustion process would lower the rate of creosote combustion. Also, if the flue gases are kept relatively hot as they pass through the chimney, less creosote will condense and deposit.

The chimney can be insulated and kept inside the heated part of the home as much as possible to reduce the heat loss from the flue gases. However, if the flue gases are kept too warm, energy will be thrown away up the chimney. Flue temperatures should be between $350^{\circ}F$ and $500^{\circ}F$ at the exit from the chimney for ideal operation.

The combustion process is controlled by the amount of air admitted to the combustion chamber, the mixing of the air with the fuel (combustible gases produced by the wood), the temperature of the air-fuel mixture and by the fuel itself. The stove design, or lack of design, will determine to a large extent the mixing processes and the temperature of the combustion process. However, the homeowner or operator controls the rate at which air is admitted to the stove and the type of fuel that is burned in the stove. Tests at the Auburn Wood Burning Laboratory (AWL) [1] indicate that the mode of operation or air inlet setting is by far the most significant parameter to creosote production.

The type of wood and the moisture content of the wood have long been thought to be important parameters in creosote production. Softwoods, pine in particular, and green or wet wood of any variety are generally accused of producing excessive amounts of creosote while seasoned hardwoods are heralded as being relatively creosote free. As a result of its reputation of producing excessive creosote and because pine is significantly less dense than most hardwoods, and hence burns more rapidly, most homeowners have excluded pine as a potential fuel source for wood burning stoves.

Between 1979 and 1980, southern pine beetles, the major insect killer of southern pines, destroyed approximately 856,000 cords of pine timber. Forest industries salvaged 64 percent of the infested timber [2]. The 36 percent not salvaged could be used as a source of energy for homes that have wood burning appliances. There is an increasing demand for wood for fuel; hence, this extensive source of fuel wood cannot be overlooked.

The tests run at Auburn show that the type and moisture content of wood burned does affect creosote formation to a small degree, but generally not in the manner traditionally thought. That is green wood and softwoods (pine in particular) actually produced less creosote than did the seasoned woods and hardwoods. This indicates that pine cannot be rejected as a source of fuel wood for wood burning stoves because of creosote production characteristics. However, all of the tests conducted at AWL were laboratory tests that were not intended to reproduce exactly conditions of a stove in a home. This study was undertaken to compare the creosote production characteristics of pine and other woods under conditions representative of a typical stove installation. In particular, the objectives were:

1) to determine if beetle-killed pine can be burned in wood burning stoves without excessive creosote production.
2) to determine how the creosote production from beetle-killed pine compares with the creosote production of other wood species at various moisture contents.

TEST SET-UP AND PROCEDURE

The test program consisted of operating four wood burning stoves for approximately one month. Periodically, the mass of creosote deposits in the chimney of each stove was measured. A different type wood was used to fire each stove; hence, the relative amounts of creosote deposit produced by each type wood could be determined.

The stoves were radiant units made of plate steel in a typical two step design. Figure 1 shows a schematic diagram of the type stove used. The four stoves were supplied by the same manufacturer and were hence, essentially identical. The stove pipe connections consisted of an adapter, a 90^{o} elbow and three 24 inch long sections of 6 inch diameter, 24 gauge stove pipe. The stove pipe was joined to a prefabricated chimney that included a roof support section, two 30 inch long sections and a chimney cap. The prefabricated chimney was a typical insulated type chimney (two stainless steel walls with 1 inch of solid packed insulation between). Figure 2 shows a schematic diagram of the stove and chimney arrangement. The four units were located in a row approximately 6 feet apart.

The stoves were operated at a very low air inlet setting to typify home operation. A thermometer was installed midway up the first section of single wall stove pipe. The air inlets on each stove were adjusted as required to maintain a flue gas temperature between 300-350^{o}F.

The stoves were charged with wood as needed to maintain the desired flue gas temperature as described above. Generally, this required chargings in the morning and afternoon. All of the stoves were fully charged at the end of each working day and allowed to burn overnight.

Each time a stove was charged, the mass of wood input, the time, and the ambient temperature were recorded. Before installation each section of stove pipe and chimney were weighed and recorded. After ten days of operation, the stove pipe and chimney sections were carefully disassembled and reweighed. To prevent loss of creosote, the sections were tapped lightly so that the very loose creosote deposits were removed. The sections were again reweighed and then reassembled on the stoves from which they came. After twenty days of operation, the weighing procedure was repeated. This time the chimneys were reassembled on different stoves. Finally, after thirty-three days of operation, the chimneys were disassembled, and a last weighing was carried out.

Two stoves were fired with mixed hardwoods (oak and hickory), one burning seasoned hardwood, the other green hardwood. The other two stoves were fired with beetle-killed pine and green pine respectively. All of the wood was in the form of split and round pieces. Random samples were taken from each wood group at various times during the tests and the moisture content was measured.

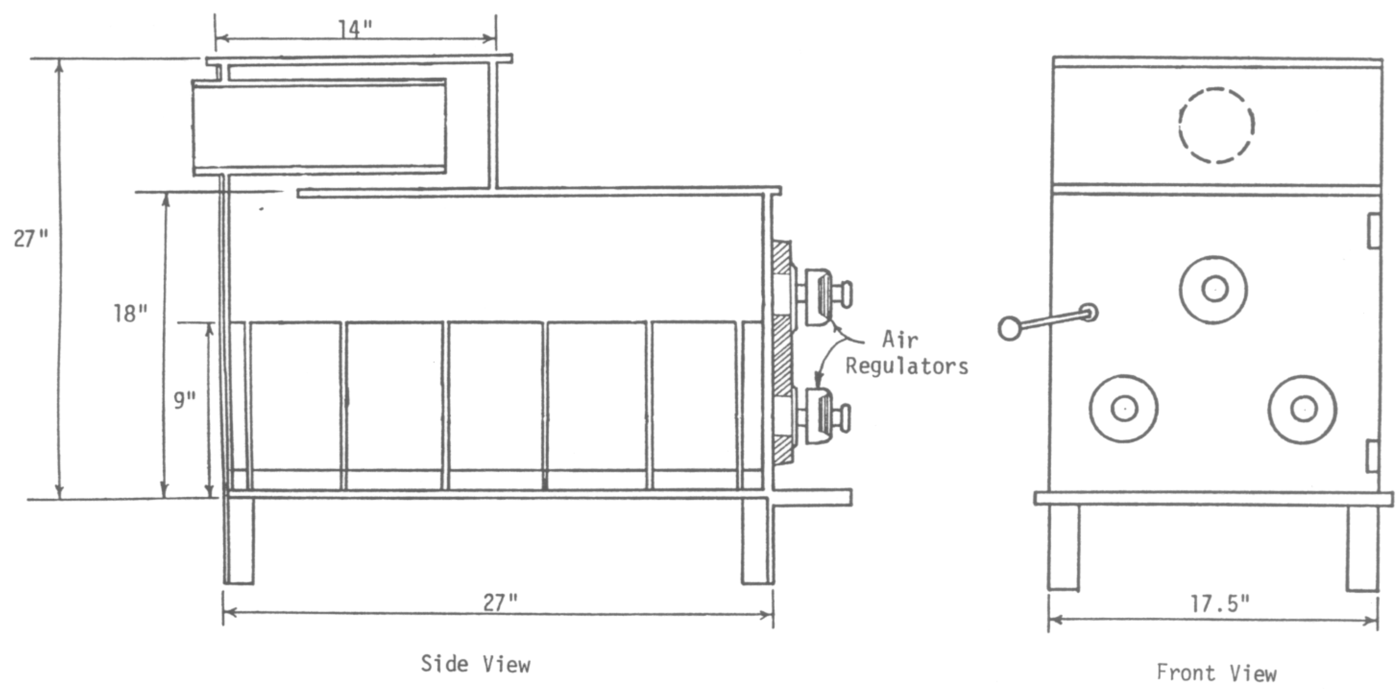

Figure 1 Schematic Diagram of Stove Used in Test

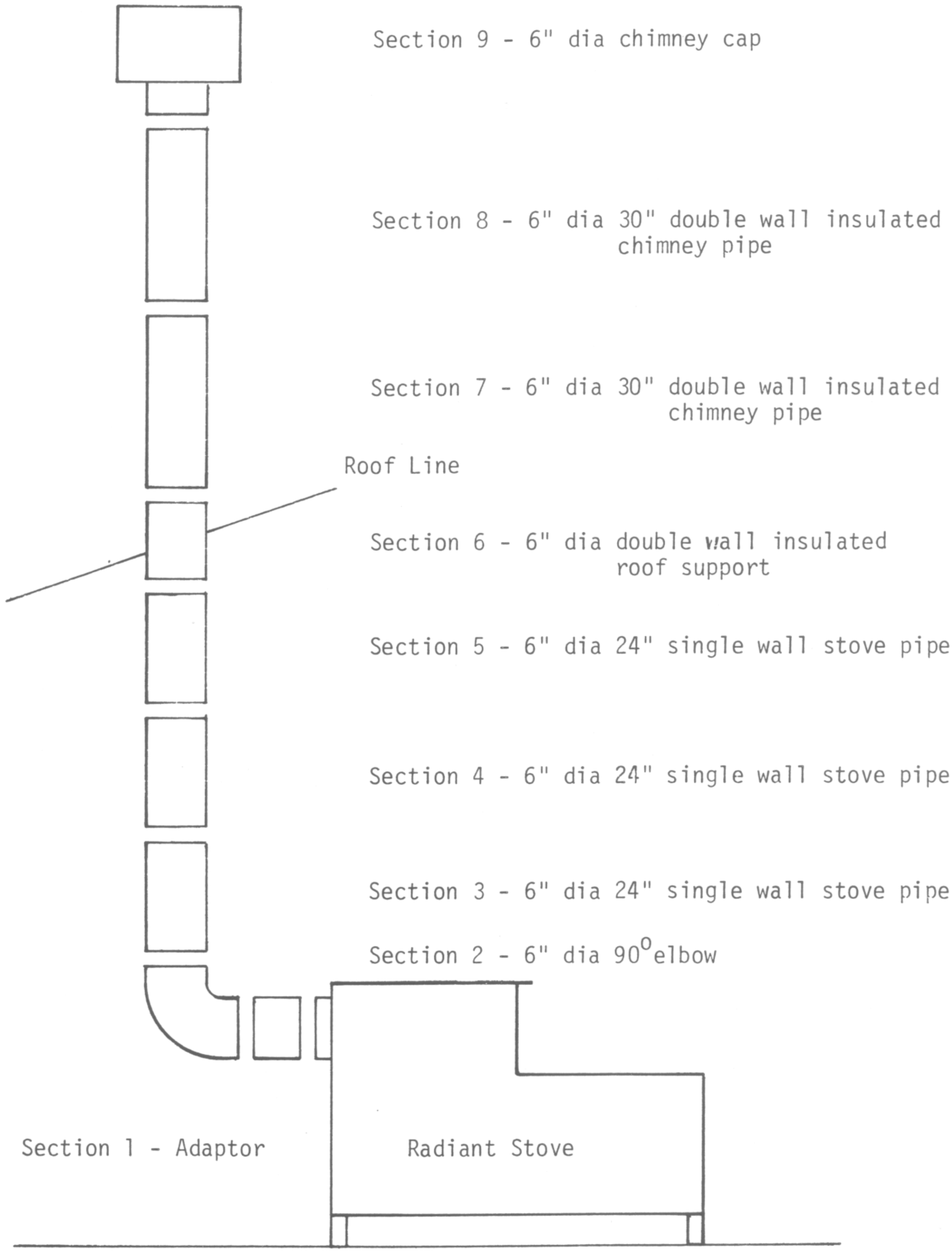

FIGURE 2 STOVE-CHIMNEY SET UP

RESULTS

All moisture contents were determined on a wet basis. The beetle-killed pine, samples from trees that had been dead approximately ten months as a result of beetle infestation, had an average moisture content of 24 percent. The green pine was the wettest wood tested; it had an average moisture content of 46 percent. The seasoned hardwood had been stored outside for approximately 1 1/2 years. It had the lowest moisture content, 14 percent. The green hardwood samples averaged 30 percent moisture.

Table 1 summarizes the test results. A total of 1545 lbm of beetle-killed pine was burned. This produced 3.61 lbm of creosote with a typical tar-like appearance. The green pine, because of its high moisture content, was difficult to start, but once a bed of coals was established, an adequate fire could be maintained. Two thousand ninety-six lbm of green pine were burned during the test, and this produced 1.81 lbm of a powdery textured creosote. The seasoned hardwood produced 3.84 lbm of creosote from 2079 lbm of wood, and 2484 lbm of green hardwood produced 3.22 lbm of creosote. The creosote produced by both the wet and seasoned hardwoods had a typical sticky, tar-like consistency.

Table 2 compares the creosote accumulation per unit of wood consumed on a wet basis and a dry basis. Both means of comparison show that the beetle-killed pine produced the largest accumulation of creosote. The beetle-killed pine was followed by the seasoned hardwood in creosote production. The green woods produced lesser amounts of creosote; the green pine produced the smallest amount of any of the test woods.

Figure 3 shows the variation of creosote accumulation versus moisture content for the tests run. The drier woods produced more creosote than did the wetter woods. A comparison of the sectional accumulation is shown in Table 3. As expected, the creosote accumulation was much greater in the lower, single wall stove pipe sections than in the upper insulated chimney sections. The green pine produced the least creosote of any of the woods. These results of this study agree with studies at AWL and at the University of Wisconsin [4]. Figure 4 shows AWL results in terms of the Creosote Number for four series of tests that compared the creosote production for different types of woods in different types of stoves. The Creosote Number [1 and 3] is a relative comparison of the amount of creosote production; the Creosote Number increases with creosote production. Note that in these results it is the type of appliance that is the significant parameter. That is, the degree of air tightness and the means of controlling the combustion air supply to the stove are more important than the type or moisture content of the wood.

TABLE 1 SUMMARY OF CREOSOTE TEST RESULTS

Wood Type	Mass of Fuel (Wood and Moisture) Consumed (lbm)	Mass of Creosote Accumulated (lbm)	Average Flue Gas Temperature °F	Average Moisture Content % (Wet Basis)
Beetle-Pine	1545	3.61	317	24.74
Green Pine	2096	1.81	317	46.14
Seasoned Hardwood	2079	3.84	313	13.54
Green Hardwood	2484	3.22	317	30.43

TABLE 2 CREOSOTE ACCUMULATION PER MASS OF WOOD

Wood Type	Mass of Creosote Accumulated (lbm)	Mass of Fuel (Wood and Moisture) Consumed (lbm)	Mass of Dry Wood Consumed (lbm)	lbm Creosote ton fuel	lbm Creosote ton dry wood
Beetle-Pine	3.61	1545	1163	4.67	6.21
Seasoned Hardwood	3.84	2079	1798	3.69	4.27
Green Hardwood	3.72	2484	1728	2.59	3.73
Green Pine	1.81	2096	1129	1.73	3.21

TABLE 3 Sectional Comparison of Creosote Accumulation in Stove Pipe and Chimney

Section*	Beetle Pine	Green Pine	Seasoned Hardwood	Green Hardwood	
1	.1063	.0542	.0836	.0591	Adapter
2	.1846	.1409	.1960	.2035	90^{o} Elbow
3	.7369	.3766	.7217	.6066	24 inch sections
4	.7689	.3191	.7385	.6141	of single wall
5	.6659	.3012	.7301	.5978	stove pipe
6	.1535	.0600	.1629	.1314	Double wall roof support
7	.3230	.1286	.4648	.3034	30 inch sections of double wall insulated chimney pipe
8	.2972	.1358	.2944	.2600	
9	.3762	.2911	.4441	.4401	chimney cap

*Section Numbers correspond to Figure 2

Creosote Accumulations in lbm

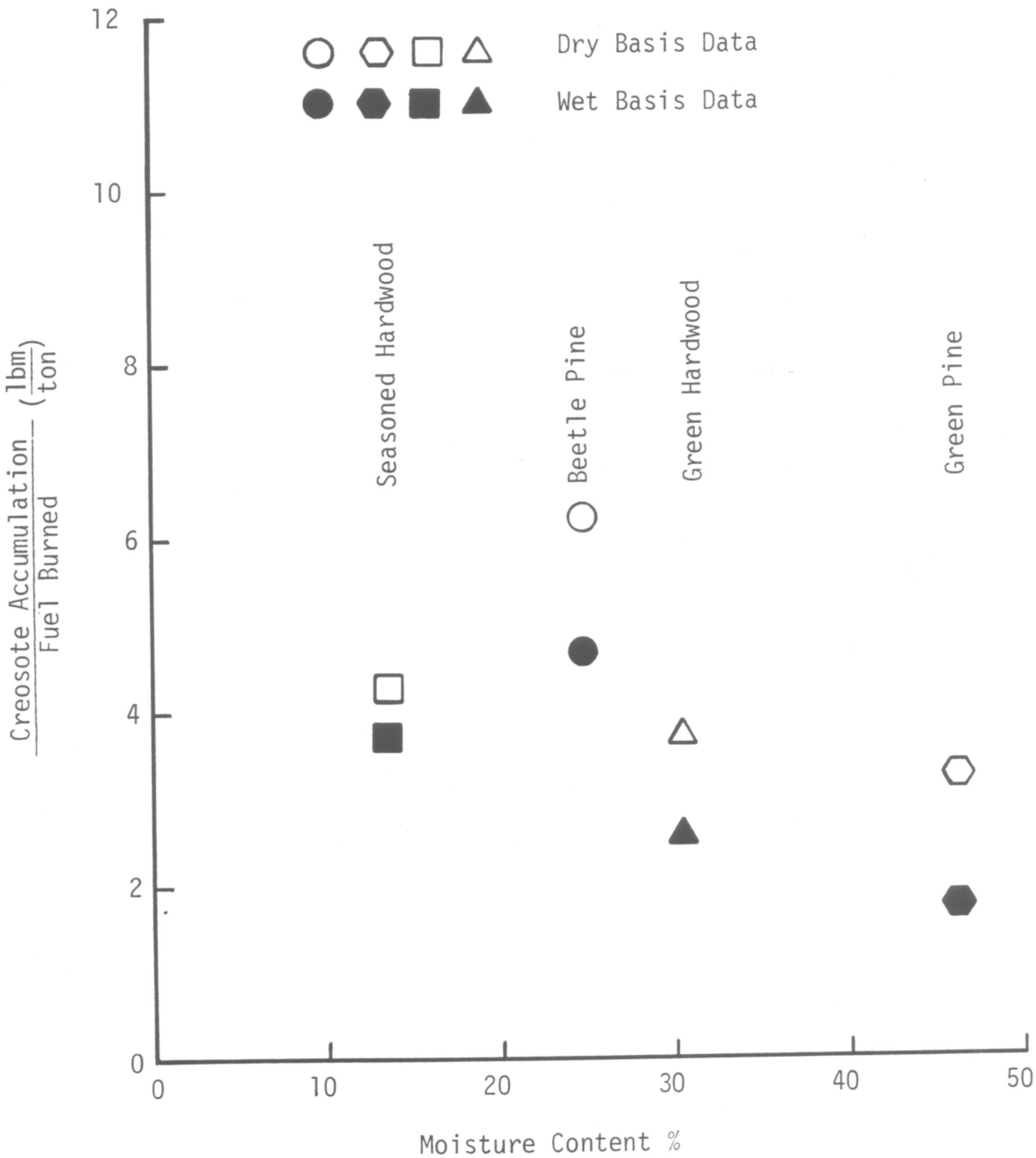

Figure 3 Creosote Accumulation vs Moisture Content

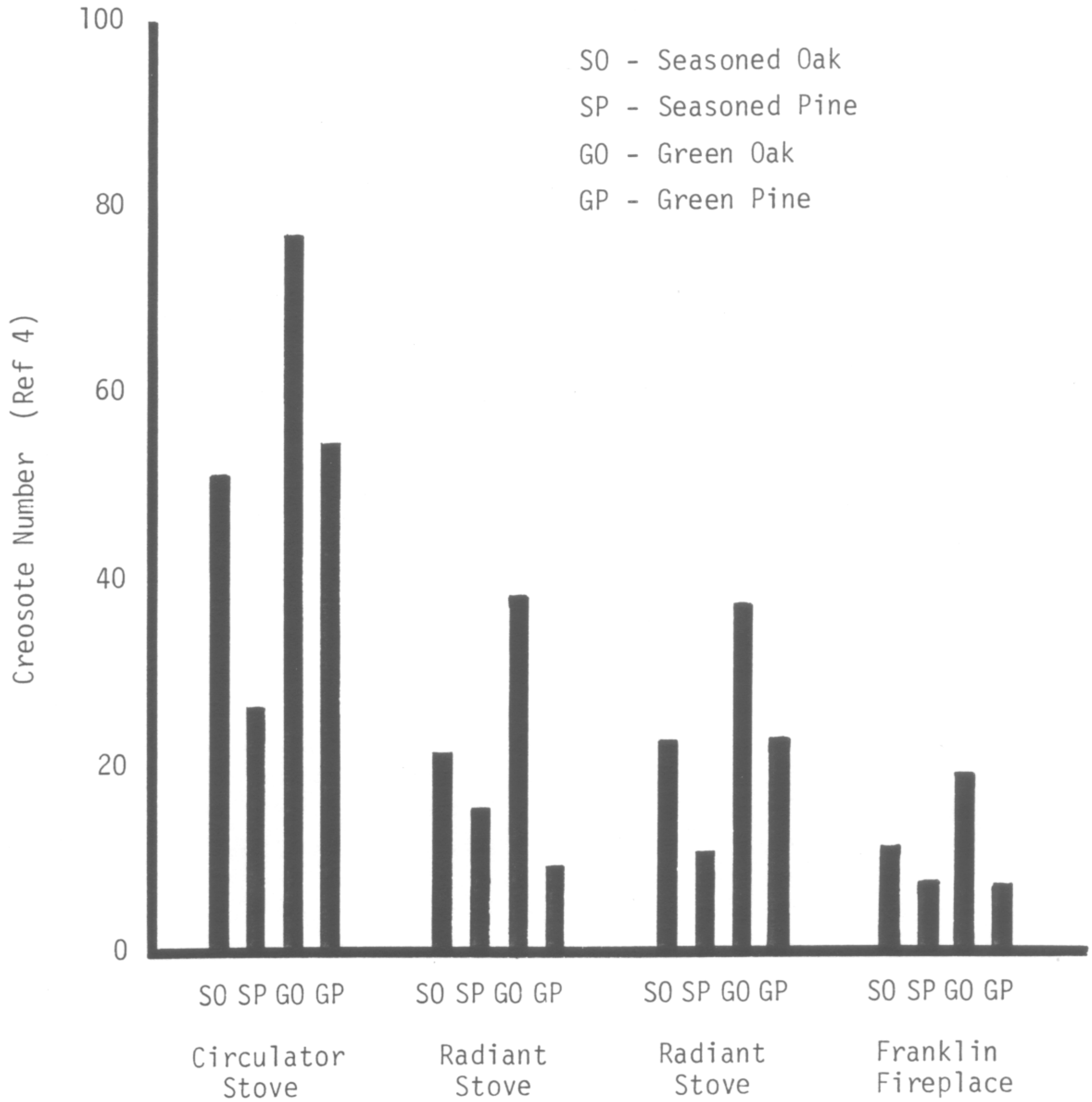

FIGURE 4 Creosote Numbers
For Different Type Appliances
(Ref 4)

CONCLUSIONS

All of the woods tested produced significant amounts of creosote accumulation. The woods with the lower moisture contents produced the largest amounts of creosote accumulation. This agrees with the results reported by others, Maxwell et al [1, 3] and Jorstad [4].

The beetle-killed wood produced more creosote than did the other woods. However, all of the woods produced significant amounts of creosote. Thus, beetle-killed pine should not be rejected as a fuel wood on the basis of creosote production.

Based on the relative creosote production, green pine would be the best choice for fuel wood. However, many parameters should be considered when obtaining fuel wood. On a dry basis there is little difference in the energy content per pound of different species of wood; but because pine is much less dense than most hardwoods, the volume of pine required to produce a given amount of heat will be greater than that of oak or hickory. This also means that a full charge of pine will not burn as long as a full charge of hardwood. The two parameters that most likely determine the source of fuel wood a homeowner selects are cost and availability. Beetle-killed pine should have an advantage over hardwoods with respect to cost.

All things considered, seasoned hardwoods are probably the best choice for fuel wood. However, as noted earlier, the demand for fuel wood is growing, and thus the large amount of beetle-killed pine cannot be overlooked. Beetle-killed pine cannot be rejected as a source of fuel wood for wood burning stoves because of creosote accumulation. This study and others show creosote accumulation is relatively unaffected by the species and moisture content of the wood burned. In fact, the only real factor is the amount of air provided to the combustion process, the type of appliance and the air inlet settings. Any type wood can be burned without undue creosote accumulation if the appliance is operated with sufficient combustion air.

Flue gas temperatures were recorded and air inlets adjusted to maintain temperature between 300-350^{o}F.

Finally, two warnings are in order. The chimney of any wood burning appliance should be of adequate construction; single wall stove pipe is not a chimney. A regular chimney maintenance should be established. This program should include periodic inspections of the chimney and flue and cleaning when necessary. Also, caution should be exercised when cutting dead standing timber. Dead limbs can fall out and the top of the tree can break out and fall. There should always be someone to watch for these dangers while the tree is being felled.

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A. Ray Shirley, Director
John W. Mixon, Chief of Forest Research

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