The Pulping of Douglas-fir

Infected with Fomes Pini

by

John P. Fleeger

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THE PULPING OF DOUGLAS-FIR
INFECTED WITH FOMES PINI

A Step in the Utilization
of our Forest Waste

I N D E X

INTRODUCTION TO THE PROBLEM

This work on Fomes pini infested wood was undertaken to devise a method for utilization of one of our forest wastes. Economically and silviculturally the wastes from our logging and milling operations have been one of the greatest mars against our American forestry practice. Under present conditions of war and advances in civilization, our former endless stands of mature forests are approaching an apparent end, and it is becoming the job of the forester to provide for the future by the development of new stands of timber and the development of new uses permitting closer utilization of the forest crops. It appears that in the future our forests may be called upon to supply many of our civilian needs, and under the investigations of chemists, engineers, and foresters a broadening sense of value for our forests is developing. In the future our forests will supply four vital types of consumer needs: trees for wood, trees for fiber, trees for chemicals, and trees for plastic materials.

Trees for Wood.

As at present, our forests will continue to supply wood for mechanical construction and fuel. New uses for wood are constantly being improved and developed: plywoods, pressed woods, impregnated woods, and fuels.

Trees for Fiber.

Two uses for fiber will be more fully developed in the future: as paper stock or as cellulose for synthetic material. For use as paper stock our forests will continue to supply wood material, but new developments and improvements will be made and fuller utilization will be possible. Synthetic goods such as cellophane and rayon are already coming from our fibers. Our forests will find much demand for these newer forest products in the future.

Trees for Chemicals.

Our forests are a potential storehouse for chemicals: pitches, tars, turpentine, resins, and oils. European countries have developed wood gas to propel vehicles and have fattened cattle with a fodder made from wood cellulose. Commercial alcohols may be gathered through the saccharification of woods. Our forests may find this to be their greatest future demand.

Trees for Plastic Material.

With the present demands for and the further development of plastic material from trees, it is evident that in the future there will be increased demands for plastic material. A large demand for plastic furniture, radios, household appliances, and other small items will probably be realized.

A recent trend in American economy has been a constant demand for closer utilization of our forests. One of the largest steps in the utilization of our forests is the utilization of logging waste. Among the causes of waste material in our forests, rot has been outstanding. Rot far exceeds any of the other causes of logging waste, except in a few cases where a wasteful milling practice is found, and may be roughly considered as five per cent or greater in stands of mature Douglas-fir. Of the rots occurring in our western forests, Fomes pini is the outstanding cause of decay. From a study of this rot it has been found that it is a cellulose leaving rot; that is, the fungus causing the rot dissolves out the lignin content of the cell wall and leaves behind apparently unchanged cellulose fibers. It is this fact which suggests the use of this wood possibly for fiber or for chemicals. The chemical use of the wood should not be lessened appreciably especially for such uses as saccharification. This report deals mainly with the use of the wood for fiber. It seems that if the fiber obtained by pulping the wood has been reduced in quality for paper stock because of length of fiber, hydration of the pulp, or color, that it might find use for other synthetic compounds such as rayon.

FOREST PRODUCTION AS AFFECTED BY ROT

The Douglas-fir ranges from British Columbia to Central California, Arizona, New Mexico and Texas. It is one of our chief lumber producing trees and its wood has the most general use of all. In certain large mature and over-mature stands of the Cascades and Coast Ranges, a large portion of valuable timber is lost due to the action of live wood rots. Of all the wood lost by rot, about eighty per cent is accounted for by Fomes pini alone. In many otherwise choice stands, this rot causes the culling of the second and third logs, and quite often the first log. This results in much of the high quality lumber being lost, as the highest portion of clear lumber is found in the lower portions of the bole. This rotted wood has been considered as a complete loss to the logging operator as its value at present does not pay for its handling. At present the only accepted commercial use for this unsound wood has been for fuel in the form of slab or hogged wood, and the price paid for this wood does not warrant the handling of the logs by the operator. If it were possible to place some value on and demand for this unsound wood, one of the largest steps toward fuller utilization of our forests would be realized.

Logging as practiced during the past years has been extremely wasteful with our forests. This has been due partly to the high prices paid and the demand for good quality lumber, and partly because of the apparent vastness of the forest empire. Today the operators are becoming aware that there is an approaching limit to the forest land and that closer methods of utilization on what they do have left and the practice of silviculture to provide for the future are the only ways to maintain our forest empire. Through education the public is learning to use lower quality wood, and through research new uses for former wastes are being developed. At present it is still the practice to leave logs in the woods which are over fifty per cent rotted, unless the sound wood present is of sufficient quality to pay for its handling. As elsewhere stated, up to fifty per cent of the volume of a stand may be culled and left standing or lying in the forest due to the action of rot. This creates quite a silvicultural problem. The logs if left on the ground smother out seedlings and are a serious fire hazard. If this hazard is removed by controlled burning there is a resulting degradation of the site quality. The trees if left standing smother out seedlings of Douglas-fir and permit inferior species, such as hemlock, to become established. The trees left standing soon stagnate in growth and retard growth of reproduction through competition for soil moisture and light. They are also a hazard due to their weakened condition as they may come crashing down from time to time in periods of storm and damage reproduction and roads.

There are several interesting items which should be noted about decay in Douglas-fir. It is known that rot is more prevalent in the southern Cascades than in the cooler northern Cascades and the Coast Ranges. An explanation offered by Boyce is that the warmer summers of the southern Cascades and the lower relative humidity may favor the growth and establishment of rot. Another item is that the growth increment of rot may equal or exceed that of the tree, especially in trees three hundred years or older. This means that in future forestry this may be the deciding age limit to which trees are allowed to grow before being cut instead of the growth increment of the tree as is often used today. Losses due to rot are also insignificant in trees up to one hundred years of age. This may mean that in phases of future forestry where quantity lumber is produced, that trees will be cut when they are about one hundred and ten years old and so decay may not be an item of importance.

According to Boyce as much as fifty per cent of a mature stand may be culled by rot and as much as twenty thousand board feet per acre left standing. The estimated loss per year in a stand may be up to five per cent but more often it is two to three per cent. A typical example given by Boyce is as follows: A stand of Douglas-fir averaging about three hundred years old was cruised at one hundred and fifty thousand board feet gross volume per acre. An estimated loss of fifteen per cent due to rot gave a net volume of one hundred twenty-seven thousand five hundred board feet per acre. Of the twenty-two thousand five hundred board feet loss, about an eighty per cent loss was due to conk rot. The total loss per acre due to Fomes pini was eighteen thousand board feet, or about thirty-six units of hogged wood.

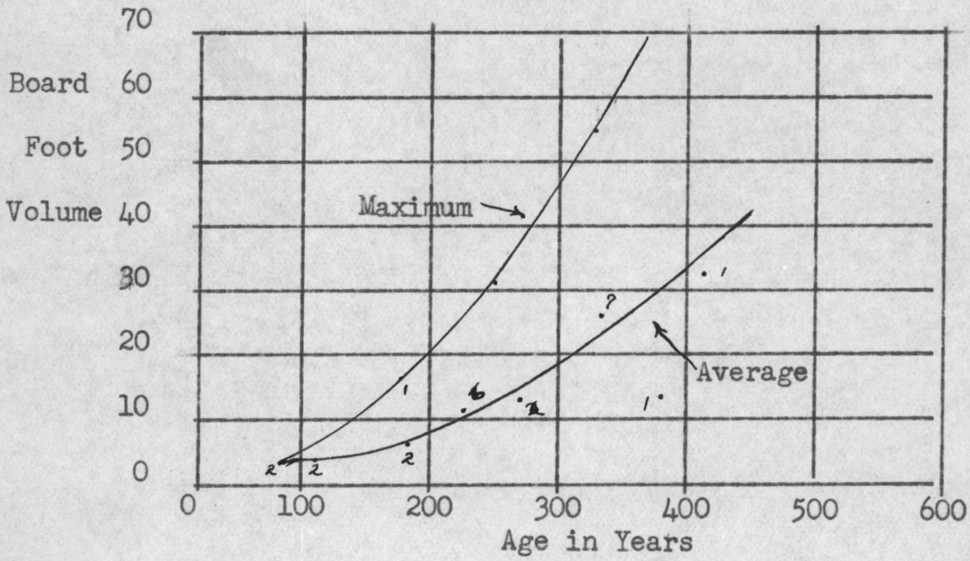
The availability of this Fomes pini infected wood is not an item of importance in consideration of its utilization, as wherever there is a mature stand of Douglas-fir, there is usually an ample supply of this unsound wood. The item of importance is the preparation and transport of the raw material to the point of utilization. This is discussed in following pages of the report.

Rot in Douglas-fir of merchantable size by plots on Site 2, grouped in 50-year age classes, based on gross board-foot volume per acre.

From U S D A #286

Age Class (Years)	Average Age	Percentage of Rot in Board-foot Volume						
		Conk Rot	Butt Rot	Top Rot	Trunk Rot	Other Rots	Total Rot	Plot Basis
51 to 100	79	0.2	0.3	Tr.	0	Tr.	0.5	2
101 to 150	117	.9	.2	0.5	0	0	1.6	2
151 to 200	184	5.9	.2	.2	1.2	Tr.	7.5	4
201 to 250	242	9.2	.5	.1	.4	Tr.	10.2	6
251 to 300	264	7.5	.9	3.3	1.3	.1	13.1	2
301 to 350	328	22.7	1.0	.6	2.3	.1	26.7	7
351 to 400	385	4.7	1.5	3.9	1.9	0	12.0	1
401 to 450	404	25.2	1.7	1.1	2.9	0	30.9	1
551 to 600	559	.8	3.1	3.2	1.1	0	8.2	1
Average	260	11.0	.7	.8	1.3	Tr.	13.8	

Percentage of rot in relation to age of Douglas-fir



Periodic increment in average gross volume and average rot volume per acre for Douglas-fir on Site 2

From U S D A #286

Board-foot Volume

Age in Years	Gross Volume	Rot Volume	Gross Increment	Rot Increment	Percentage of Rot
50	20,000	0	20,000	0	0
100	69,000	690	49,000	690	1
150	110,000	4,400	41,000	3,710	4
200	136,000	10,470	26,000	6,070	7.7
250	158,000	19,120	22,000	8,650	12.1
300	174,000	31,500	16,000	12,380	18.1
350	186,000	47,620	12,000	16,120	25.6
400	196,000	69,970	10,000	22,350	35.7
450	203,000	101,500	7,000	31,530	50.0

Periodic increment in average gross volume and maximum rot volume per acre for Douglas-fir on Site 2

Board foot Volume

Age in Years	Gross Volume	Rot Volume	Gross Increment	Rot Increment	Percentage of Rot
50	20,000	0	20,000	0	0
100	69,000	1,100	49,000	1,100	1.6
150	110,000	9,460	41,000	8,360	8.6
200	136,000	24,620	26,000	15,160	18.1
250	158,000	48,000	22,000	23,890	30.7
300	174,000	81,610	16,000	33,100	46.9
350	186,000	130,200	12,000	48,590	70.0

CHARACTERISTICS OF CONK ROT, OR RED-RING ROT, AS IT AFFECTS DOUGLAS-FIR

Fomes pini or Trametes pini

Fomes pini is a white pocket rot or one of the cellulose leaving rots. It is commonly referred to as a stringy rot due to its effect upon the wood. It is common to conifers, occurring especially in larch, pine, spruce, hemlock, true firs and Douglas-fir. It is the main heart rot of Douglas-fir. The rot usually becomes established after the tree is fifty years old. In Douglas-fir the age of the tree may be a good reference as to the extent of the rot. In most cases the older the stand the more extensive is the rot. Of the rot occurring in Douglas-fir, Fomes pini accounts for 80% of the rotted volume. The percentage of rot occurring in merchantable stands may run about 38% of the board foot volume and about 22% of the cubic foot volume. Only the heartwood of Douglas-fir is affected and when the log is viewed in cross section the rot appears in patchy, crescent-shaped, or circular areas. The incipient stage does not apparently weaken the wood, and much of it can be used for airplane construction. The hyphae do not normally extend beyond the discolored portion.

Early Stage:

1. Pink, reddish, or purplish discoloration of the heartwood.
2. Wood is firm and shows no pockets.
3. Heavy infiltrations of resins often occur.

Late Stage:

1. Of same color as the early stage.
2. Wood is weakened by few to many small pockets lined with

cellulose fibers. Pockets run parallel to the grain.

3. The late stage is bounded by discolorations of the early stage.

Extent of the Rot

The following average figures are given for the extent of the rot in Douglas-fir:

Occurring as a Trunk Rot

The rot extends about twenty feet beyond the last entry court and about ten feet beyond the last swollen knot. It may occur at any place along the bole where there has been a point of entry.

Occurring as a Butt Rot

The rot normally extends from six to ten feet into the butt log. The point of entry is usually an old fire scar.

THE PULPING OF DOUGLAS-FIR INFECTED WITH FOMES PINI

The pulping of Douglas-fir which has been infected with Fomes pini has previously been considered by its effects upon the quality of pulp produced under standard pulping conditions. It has been conceeded by many that the pulp produced from this unsound wood is inferior in quality although a satisfactory yield, as compared with sound wood, was obtainable. (1, 2, 3.) The reason for this decision in many cases was the result of observing the results of pulping this unsound wood in addition to sound wood and under conditions favorable for sound wood. As this infected wood has been definitely changed in composition and structure (8), it is reasonable to expect that special conditions should be used for its pulping. If a favorable set of conditions were established for this wood, it is also reasonable to expect that a fair to good pulp would result and that this pulp could satisfactorily fulfill many of the market demands which are now being supplied with pulp made only from sound wood.

Among the disadvantages which have been presented against the pulping of this unsound Douglas-fir are: (1) Large mechanical losses; (2) Production of the mill cannot be maintained; (3) Strength of the pulp is decreased; (4) Loss of strength in bleaching; (5) Increased costs in handling; (6) Inferior quality.

Large Mechanical Losses

According to Johnsen and Lee (3) and upon figures based upon rotted white spruce the losses may range from 5.6% to 17.0% depending upon the various stages of the rot. The name of the rot is not stated and so the figures may be for a friable instead of a stringy rot. It is right to assume, however, that there will be more splintering and powdering as compared with sound wood.

Production of the Mill Cannot Be Maintained

In order to maintain the production of the mill it is necessary to shorten the cooking time by use of a high temperature when unsound wood is being used, but with this type of wood high temperatures should be avoided. (3). In the preceding statement Johnsen and Lee are considering the general use of infected wood. With Fomes pini infected wood it may be possible to maintain production as the cellulose content is not appreciably decreased. (10).

Strength of the Pulp Is Decreased

Pulp from rotted wood hydrates more readily and with excessive hydration strength decreases. (3). Maximum strength is reached at an early stage in the beating, after which the strength rapidly falls off. In unbeaten pulp there is no reduction of strength (9) as compared with unbeaten pulp of sound wood.

Loss of Strength in Bleaching

Rue and Miller (2) state that the loss of strength in the advance stage of Fomes pini rot is considerable. Modern bleaching methods may invalidate their conclusions.

Increased Costs in Handling

In order to use a digester for cooking infected wood it is necessary to maintain a constant supply to it. Under present conditions it would be quite costly to separate decayed from sound wood. Under future developments of a portable mill and hog it may be possible to do this at the source.

Inferior Quality

The quality of the pulp definitely seems to be reduced so that under demands for high quality products it could not be used, but it might ideally supply pulp for cardboard boxes and wrapping papers. Under conditions demanding high burst, tear, or folding strength it would probably prove inferior.

In addition to the possibilities of overcoming the difficulties in pulping of conk rotted Douglas-fir as discussed above, the following advantages should be pointed out: (1) Utilization of a waste product; (2) Low cost of raw material; (3) Penetration of heartwood is increased; (4) Less amounts of reactants necessary.

Utilization of a Waste Product

Under present conditions and demands for only high quality products there is a large amount of wood culled by this rot. For silvicultural and economic reasons it would be favorable to utilize this large amount of waste.

Low Cost of Raw Material

Since the wood is at present a loss to the logging companies, it could be had for little or no stumpage cost. The only large cost would occur with the hauling and handling of the wood. Under conditions to be described later in the report, this wood could compete favorably with the present sources of sound wood.

Penetration of Heartwood Is Increased

One of the problems in pulping Douglas-fir is that the heartwood takes longer to pulp than the sapwood. (3). In many cases this results in the pulp from the sapwood being overcooked. The heartwood of Douglas-fir infected with Fomes pini is penetrated much more rapidly as compared with sound wood. (3). This will result in the more uniform cooking of the pulps from both the sapwood and heartwood.

Less Amounts of Reactants Necessary

The lignin in rotted wood has been decreased and the cellulose lignin ratio has been slightly raised. (3, 10). Since the cellulose has already been freed and the amount of lignin decreased, the quantity of necessary reactants may be somewhat reduced.

Conditions which should be favorable for pulping Douglas-fir which has been infected with Fomes pini are: lower concentration of chemicals without decreasing the total chemical, which increases the yield, strength and bleachability; increasing the sulphur content, which in turn increases tearing strength up to 20%, increases folding resistance up to 500%, reduces bleach consumption, and reduces loss of cellulose up to 50% in the first one-half hour of cooking; lower temperatures which result in a larger yield.

KRAFT PULPING

The Kraft process is especially adapted to the pulping of long fibered, resinous woods. The Kraft pulp is of a dark brown shade and is usually unbleached since the process would require immense quantities of bleach. The great strength of the pulp along with its color makes it ideal for wrapping and bag papers. The pulp produced by the process is intentionally undercooked in order to produce the strong stock. The chemicals used in the process are industrially available and have the added advantage that they can be largely recovered after use. Several valuable by-products are also produced and are finding commercial use. They are chiefly methyl alcohol, oil of turpentine, and various resins. One of the chief objections to the process is the formation of ill-smelling odors.

The commercial cooking liquors consist of the following components:

Sodium hydroxide	$NaOH$
Sodium sulfide	Na_2S
Sodium carbonate	Na_2CO_3
Sodium sulfate	Na_2SO_4
Sodium thiosulfate	$Na_2S_2O_3$

Laboratory liquors consist usually of only the first two compounds. A high percentage of the latter three named is highly unfavorable and they are introduced through the ineffective operation of the recovery plant.

Chemistry of the Kraft Process

The sodium hydroxide is the chemical of chief reaction; the sodium sulfide being used but little during the cook. The function of the sodium sulfide is to act primarily as a reservoir for the hydroxyl ion. The sodium hydroxide has little effect upon the cellulose content of the wood except that portion which is carried away as collodial material. The main reaction taking place is the breaking down of cell structure by making soluble sodium compounds of the lignin and resinous material.

Details of the Process

Wood used for the Kraft process does not require the extreme care exercised to have all the bark removed as compared with the other processes. Chips are usually of a seven-eighths inch size and are stored in bins until ready for use. After the proper amount of chips has been placed in the digester the liquor, commonly called the white liquor, is run in and the digester is closed. A penetration period in which the temperature and pressure are slowly raised to that of the cook may last from one to three hours. The time of the cook varies from one to three hours, but short cooks predominate with the total time for the penetration and cooking period lasting for about three or three and one-half hours. After the cook has been completed the pressure is relieved and the cook is blown into the blow pit. The pulp is next washed thoroughly in order to give a pure stock and to recover as much of the chemical as is possible. This stock is then ready to be made into paper.

The waste liquors of the cook, commonly called black liquor, go into a recovery system, the efficient operation of which results in the recovery of a high percentage of the chemicals.

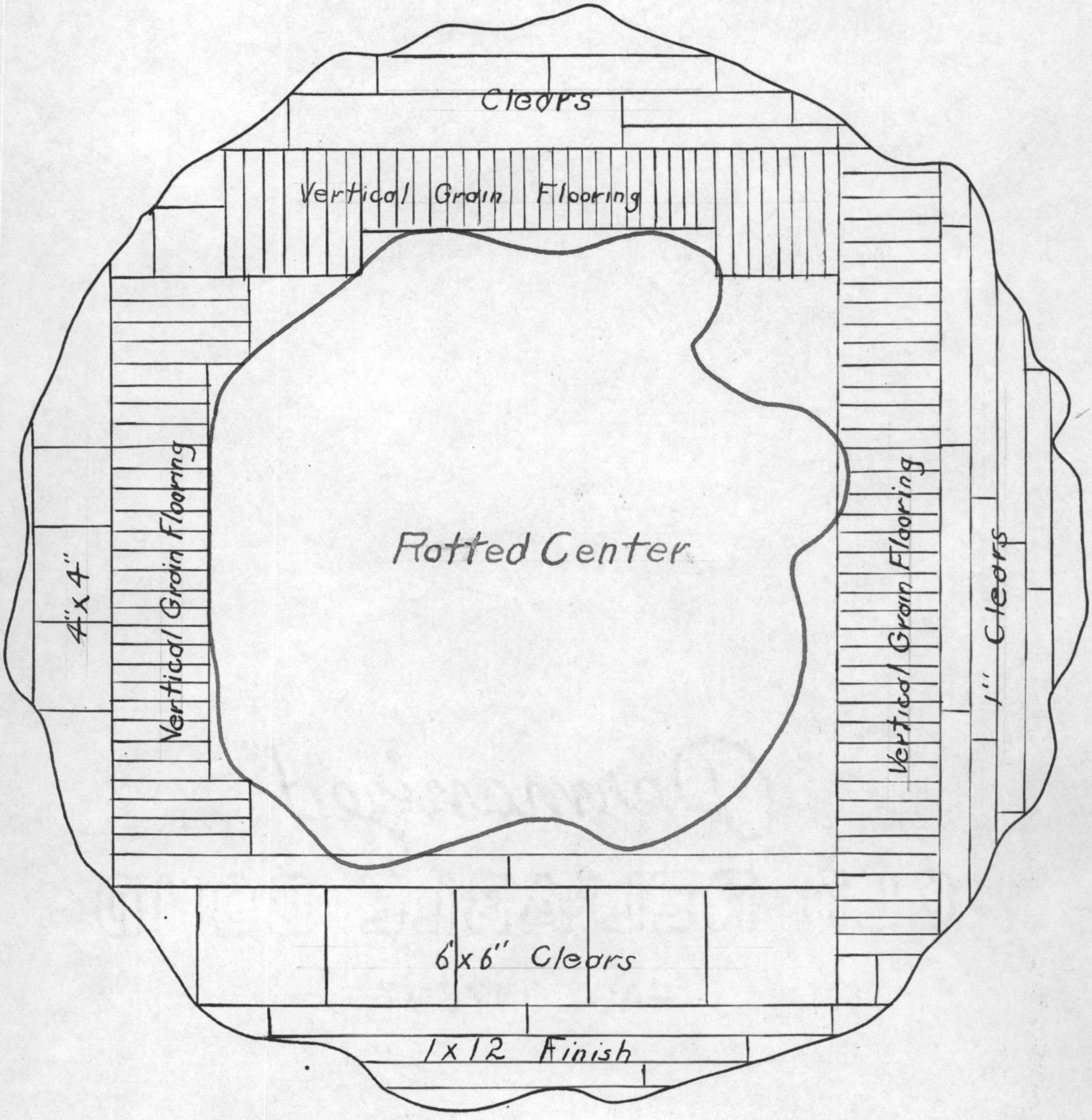
Recovery Process

The black liquor as it leaves the blow pit is next sent through a system of evaporators. This liquor contains sodium compounds of the wood, unused chemicals, collodial cellulose, and some organic acids. The purpose of the evaporators is to concentrate the material down to the point where it will satisfactorily support its own combustion. This thickened material is next sprayed into a furnace where it is dried completely and partly burned as it falls to the bottom of the pit. Much of the sulphur is lost as sulphur dioxide in this process. The ash that collects at the bottom is composed chiefly of carbon, sodium carbonate, and sodium sulfate. More sodium sulfate is added to make up for the sulphur lost, and then air is forced through the mixture causing the already hot material to burn. This burning results in molten sodium carbonate and sodium sulfide which are drawn off at the bottom and dissolved in water. The heat formed within this combination furnace and smelter can be used to operate the digester, the evaporators, and the rotary furnace used to heat the calcium carbonate sludge formed later. To the solution of sodium carbonate and sodium sulfide is added calcium hydroxide which unites with the sodium carbonate to form sodium hydroxide and calcium carbonate as a precipitate. The solution of sodium hydroxide and sodium sulfide is then drawn off from this causticizing tank, diluted to the correct concentration and used again in the digesters. The lime sludge formed in the causticizing tank is drawn off and heated in the rotary furnace. The sludge contains some carbon and calcium carbonate, the heating of which results in the formation of calcium oxide and carbon dioxide. The calcium oxide is added to water to form calcium hydroxide and then is used over again.

PROPOSED METHOD FOR HANDLING WASTE

The logs and trees remaining in the forest present one of the greatest difficulties confronting the development of a use for this waste wood. As they are primarily of mature timber their size is such as requires the use of heavy and costly equipment. For the operator intending to use them for some purpose such as pulping their size will have to be reduced to that which can be handled by light equipment. The best method for salvaging this waste timber is something which will have to be determined by a series of experiments. The following method is proposed for use by a pulpwood operator. Parts of this method are being worked out by some of the progressive logging operators for further utilization of their holdings.

The pulpwood operator to obtain the waste wood would use a follow-up logging operation. The waste as he would find it would be in the form of logs already bucked, but culled, and as standing trees. The pulpwood operator could use the same roads, settings and landings as used by the preceding logging operator to obtain his logs by. The first part of the field operation would be to fall and buck the standing trees and to yard or skid them to the landing. The second step in the operation is the one which may involve the success or failure of the method. The proposed method is the use of a portable mill and hog to reduce the wood to a size small enough to enable the use of light equipment. It must be remembered that the trees left standing were culled by the logging operator because the merchantable wood present did not warrant its handling by his methods. It should also be remembered that Fomes pini is primarily a heartwood rot, and so there is usually a ring of clear, high grade lumber to be found in the logs culled, especially in the first and second



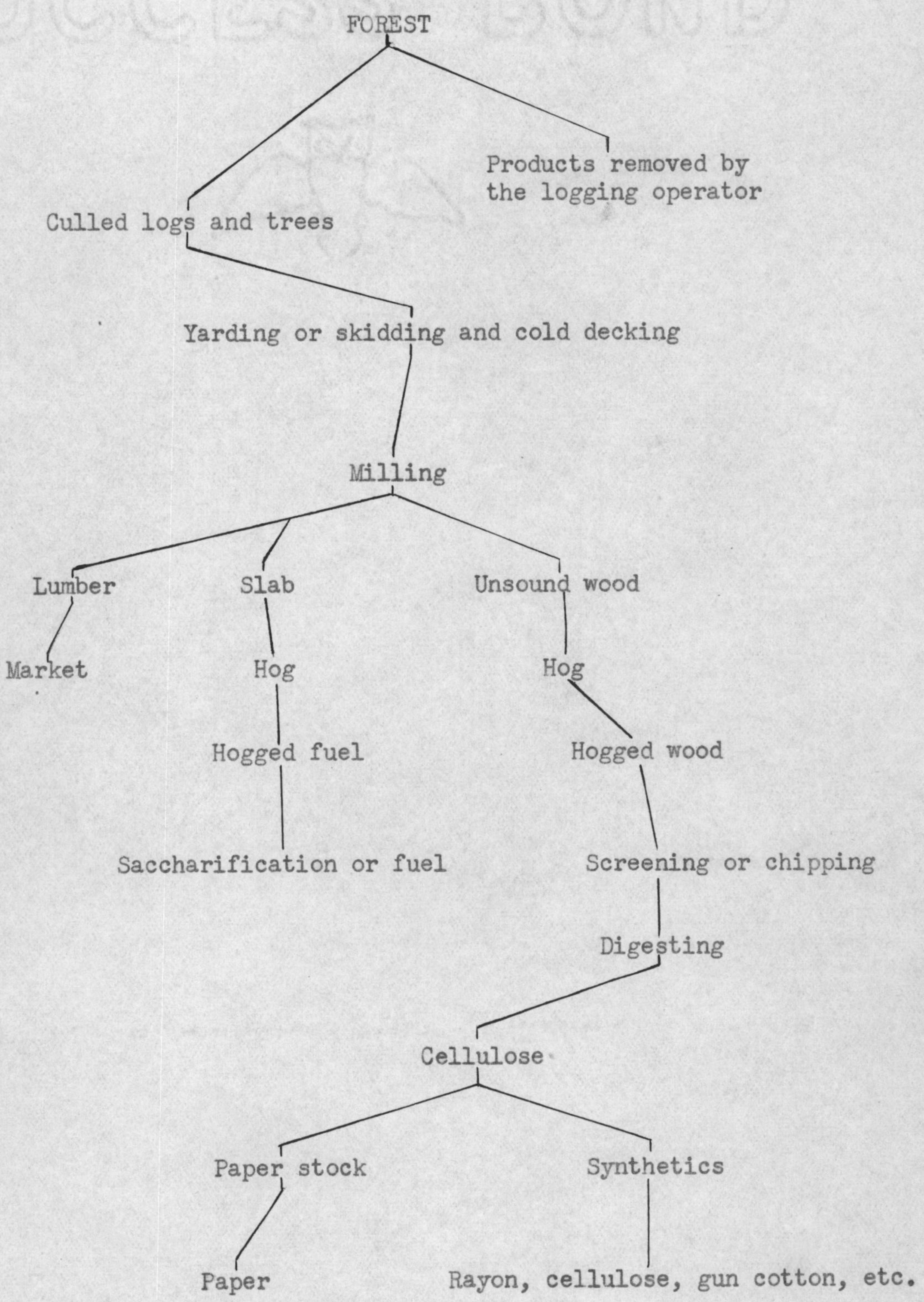
DIAGRAMATIC REPRESENTATION OF THE METHOD
OF UTILIZING A PRACTICALLY ROTTED LOG

The volume of merchantable lumber to be obtained from each log will vary with the size and placement of the rot. The volume of clear and high grade lumber will vary directly with the diameter of the log and the density of the stand which produced it.

logs. The acquiring of this valuable lumber may be the item which will make feasible the cost of the necessary field equipment. After the logs have been brought into the landing it is proposed to send them through the portable mill. The mill could be either of a circular or gang saw type, but probably the gang saw type would be more satisfactory. In this operation, first the bark will be slabbed off and this can be used as slab or as hogged fuel. Next the ring of valuable lumber will be removed and stacked for merchandizing. According to the report on portable mills in the Journal of Forestry, the mill could pay for all parts of milling, yarding, equipment, supplies, camp, labor and stumpage. They give the total cost per thousand board feet of lumber to be $12.70 while the market value was $26.21, Considering the wood to be handled by the mill to be half rotted, the cost per thousand board feet of merchantable lumber would rise to $25.40 and would result in the unsound wood being produced almost free of initial cost. These stated figures are an average value for conditions existing in southern pine, and so do not apply to operating in the Douglas-fir region. It is reasonable to expect, considering the high quality wood available, that the mill could produce material for pulping at very little cost if the lumber present is of sufficient quantity and quality to pay for the field operation. This may result in the establishment of a marginal log, the specifications of which would limit the type and condition of log brought to the mill.

The following pages show the representative costs involved and the method presented for the handling of waste wood.

FLOW CHART OF UTILIZATION METHOD



OPERATING COSTS FOR A PORTABLE HOG

Based upon report from the Gurrier Mill, Eugene, Oregon.

35" hog 50 HP motor

Production 16-20 cords per 8 hours

75% capacity 7 cds/hr or 56 cds/day

One cord produces a little more than one unit hogged fuel

Operating cost

1. Interest @ 6% of average investment		$80.70
1. Hog	$1,200.00	
2. Motor	350.00	
3. Bins and Conveyors	1,100.00	
2. Depreciation		
1. Hog and Motor @ 10%		159.00
2. Bins and Conveyors @ 5%		55.00
	Total	$294.70/yr.

Average operating cost per day is $1.47

	20 units/day	56 units/day
Overhead or risk	$1.47	$1.47
Knives	1.50	1.75
Power	.80	2.80
Labor	6.00	6.00
Maintenance	.50	.75
Totals	$10.27/day	$12.77/day
or	$0.51/unit	$0.23/unit

Average value for Corvallis Lumber Company, Silverton Mill, Gurrier Mill and the Roseberg Mill is $0.44/unit.

OPERATING COSTS FOR A PORTABLE BAND MILL

Based upon the New York State College of Forestry bulletin

Three units to a saw

1. Band saw and feed works
2. Carriage, mounted on one section of carriage tracks
3. 60 HP motor

Cost is approximately $500.00 to $700.00/M of daily output.

From the Journal of Forestry report upon portable mills the cost per thousand board feet is about $12.50.

TRUCKING COSTS

For one 9-unit truck

Based upon G. Eugene Tower's Report

Initial investment - Chassis, cab, trailer		$3,890.00
Fixed charges		$714.00/year
Interest		
License		
P.V.C. License		
Insurance		
Operating risk and overhead		
Operating costs per mile @ 25,000 miles/year -		$0.1543/mile
Depreciation	$0.0246	
Tires	.0404	
Maintenance, Lubrication, Rprs.	.0340	
Gas @ 18¢/gal.	.0257	
Oil @ 50¢/gal.	.0010	
Fixed expense	.0286	
Driver's wages	$8.60/day	

Considering an average round trip haul of 60 miles the cost per 9-unit load is $9.25 plus $8.60 or $17.85.

Average cost per unit for a 60-mile round trip is $1.99.

With the assumption that the quality and quantity of wood obtained by the mill will pay for the milling, yarding, equipment, supplies, camp, labor, and stumpage (7) the cost per unit of hogged wood delivered at the mill is:

Hogging cost	$0.44
Transporting cost	1.99
Loading and unloading by conveyor	.81
Total cost	$3.24

In comparison with costs as presented in the U. S. D. A. Occasional Bulletin 9 the cost for producing pulp wood is:

Falling and bucking cost	$1.553
Loading and unloading by hand	.744
Fixed cost	$2.297

Transportation costs	
Unimproved roads	.320
graded dirt roads	.134
surfaced roads	.102

For a 60-mile round trip the cost is at least $6.12 plus $2.297 or $8.42/cord. The transportation figures seem to be excessively high as compared with the costs stated previously. Even if the transportation cost were lowered to that of $1.99 as for hogged wood, the cost of hogged wood would be cheaper.

It seems that the above figures show that the cost of producing pulp material from decayed Douglas-fir can compete favorably with cord wood produced and hauled by present methods.

SUMMARY

The preceding pages of this report seem to indicate that it is possible and that it may prove profitable to develop and utilize this source of waste material. Experimental tests upon the quality and quantity of paper stock produced should prove decisively whether or not it is feasible to use this material for fiber. If it is not suitable for fiber its structural composition indicates that other uses, especially saccharification, can be developed for it. It is intended that at a future date a section on experimental tests on this wood will be added to this report.

Among the arguments presented for the utilization of this waste, the fact that this huge amount of waste is a mar against our American economic and forestry practices seems to outweigh all of the other arguments presented against the utilization of the wood. It is believed that in the next few years our country will make great strides in the utilization of her waste forest materials, and that the using of this Douglas-fir waste will be one of the greatest strides taken.

B I B L I O G R A P H Y

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1. Hubert, Ernest E.

   Outline of Forest Pathology

2. Boyce, J. S. USDA No. 286

   Decay and Other Losses in Douglas-fir

3. Boyce, J. S. USDA No. 1163

   A Study of Decay in Douglas-fir

4. Friedman, Leo; Zill, L. P.; Englert, Robert

   Progress Report - Utilization of Waste Wood

5. Olzendam, Roderic 39th Annual Convention of Pac. Adv. Assoc.

   After the War - Wood

Forest Production - As Affected by Rot

1. Boyce, J. S. USDA No. 286

   Decay and Other Losses in Douglas-fir

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