Economic perspective on harvesting and physical constraints on utilizing small, dead lodgepole pine

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Abstract

This research was conducted in order to evaluate the practicality and potential for harvesting and utilizing small, dead lodgepole pine. Small diameter, dead lodgepole pine occurs in concentrated areas in various regions of western North America, often as a direct result of bark beetle infestations. The research included a case study demonstration harvest of small, dead lodgepole pine on the Umatilla National Forest in eastern Oregon during a 3-month period in 1979. Statistics were obtained during the demonstration harvest on costs, energy requirements, and physical characteristics of the small, dead lodgepole timber. An informal market survey of several dozen local timber buyers was conducted in order to ascertain the current problems and potential in utilizing small diameter, dead lodgepole pine.

The results of the research indicated that 1) in harvesting, the cost of producing chips alone was lower and less variable than the cost of producing roundwood and chips. 2) However, chips and roundwood were found to have different and highly variable market prices over time. 3) Small, dead lodgepole was found to be currently acceptable and used for a variety of products, produced from both roundwood and chips. Harvesting of the small, dead timber was found to present no major difficulties with a conventional rubber-tired feller buncher and skidder type harvesting system, so far as the physical characteristics of the timber were concerned. 4) Energy inputs to harvesting were found to be quite small (6% to 7%) relative to the recoverable heat energy of the dead lodgepole if used as fuel. 5) The cost-to-energy-value ratio of delivered dead lodgepole chips was less than the price-to-energy-value ratio of oil and gas, but not less than that for coal. However, the price-to-energy-value ratio of dead lodgepole chips is likely to be higher and more variable than the cost ratio, owing to alternative and competing end uses and variable market prices. This research was conducted by the U.S. Forest Service, with support in part from the U.S. Department of Energy.

In this study questions related to harvesting and utilizing small, dead softwood timber were examined. Extensive stands of small, dead timber occur in various regions. Bark beetles alone kill millions of softwood trees in the United States each year (3). In the western United States bark beetles commonly invade overcrowded stands of small diameter lodgepole pine. In such stands of dead and deteriorating timber, harvesting and product recovery are easily viewed as uneconomical. Such timber typically represents a residue, pest, and fire hazard in the forest, and a residue raw material in the market. Perhaps if the economic potential of small, dead timber was well understood, there would be better efforts aimed at removing such timber from the forest and utilizing it for various products.

One question examined was whether sorting out roundwood has an economic advantage over chipping all of the material during harvesting. A second question

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was whether small, dead timber is acceptable for primary products in view of its small size and typical defects such as drying checks and blue stain. A third question was whether harvesting is exceptionally difficult because of the size and physical quality of the timber. A fourth question was how the energy inputs to harvesting compare to the fuel energy value of the harvested wood. Finally, the economic potential of using small, dead timber for fuel was examined also.

Case study

An actual demonstration harvest of small diameter, dead lodgepole pine was conducted on the Umatilla National Forest in the Blue Mountain area of eastern Oregon. There are 525,000 acres of lodgepole pine forest type in the Blue Mountain area (2). Forest management staff at the Umatilla National Forest agree that most lodgepole pine stands in the area are dead or dying as the result of a mountain pine beetle infestation that began in the 1970s. Large concentrated stands of gray, dead timber are visible throughout the area. Similar infestations have occurred in other areas, including the Bitterroot Valley area of Montana and the Targhee National Forest in Idaho, and such infestations are likely to occur in other areas because of the abundance of lodgepole pine throughout western North America.

The case study harvest was conducted, from July to September 1979, on six harvest sites that totaled over 130 acres. The harvest sites were located south of Pendleton, Oreg., on the south half of the Umatilla National Forest. The harvesting system was very conventional including several rubber-tired feller bunchers and grapple skidders. This type of equipment is used commonly throughout forested regions of North America.

Feller bunchers sheared and accumulated three to five stems at a time. Grapple skidders moved the felled and bunched stems to central landings. At the landings, stems were either chipped with a mobile chipper or sorted and trimmed into logs with a mobile log trimmer, depending on the decision of the logging operator for a given harvest site. On two sites, only whole-tree chips were produced because, in the view of the logging operator, the trees were generally too small for adequate recovery of roundwood products. Chips were transported to a local pulpmill in chip vans. Roundwood was transported on log trucks to various local buyers. Transportation distances were, in general, about 50 miles one way for roundwood and chips.

A distribution of large-end-of-stem diameter was obtained by random sampling of harvested stems on all six harvest sites (Fig. 1). The distribution shows the generally small size of the timber. Average large-end-of-stem diameter was only 8 inches. Many stems were only 4 to 5 inches in diameter at the large end. Small size, severe drying checks, weathering, and blue stain are all typical physical characteristics of this type of timber. A distribution of moisture content in logs and chips was also obtained by random sampling on all six harvest sites (Fig. 2). The moisture content distribution illustrates the dryness of the dead lodgepole timber, the bulk of which had moisture content less than 20 percent on a wet weight basis (25% ovendry basis).

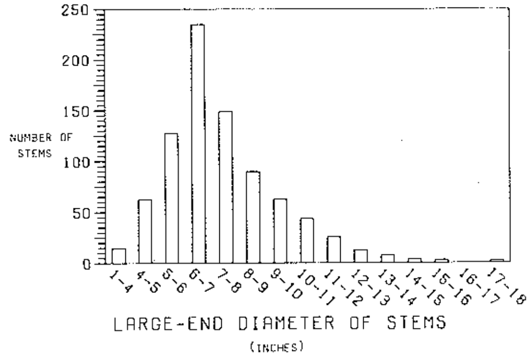

Figure 1. — Large-end diameter distribution in random sample of stems skidded to landings, combined for all six harvest units.

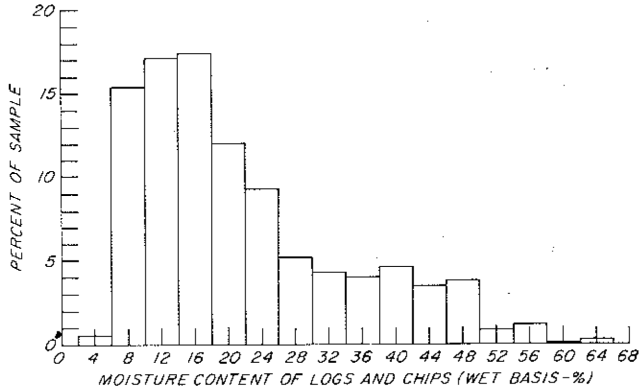

Figure 2. — Distribution of 345 random samples of log and chip moisture content taken during the study harvest of beetle-infested lodgepole pine.

A summary table of empirical cost statistics is provided (Table 1), based on detailed data that were obtained during the demonstration harvest. The cost statistics were allocated according to functional elements of the harvesting system. The cost statistics in the table are averages, based on the aggregate data obtained from all six harvest sites.

Summary results

This research was primarily a case study based on the demonstration harvest and dead lodgepole pine situation in eastern Oregon. However, selected results are worth considering in similar situations that involve harvesting and utilization of small, dead softwood timber.

Chips versus roundwood and chips

Small, dead timber, including dead lodgepole pine, is used for various products. Products generally fall into two major categories — roundwood products and chip products. Roundwood products include lumber, house logs (for log homes), posts, poles, mine timbers, treated wood products, and various other solid wood products. Chips are used mainly for pulp but also for fuel.

In harvesting small, dead timber, an efficient logging firm has a choice between producing whole-tree

TABLE 1. — *Average production costs in dollars per ovendry ton (July to September 1979) for case study harvest of small, dead lodgepole pine in eastern Oregon.*

Operation	Average production costs for:					
	Whole-tree chips		Roundwood and chips			
	($)	(%)	($)	(%)	($)	(%)
Felling and bunching	5.75	(16)[a]	5.70	(10)	6.21	(13)
Skidding	3.76	(11)	5.63	(10)	6.14	(13)
Chipping	5.87	(17)	—		10.11	(21)
Log handling	—		21.70	(38)	—	
Miscellaneous operations	3.44	(10)	4.14	(7)	4.51	(10)
Transportation	6.08	(17)	7.05	(12)	6.29	(13)
Stumpage (USFS fees)	2.30	(6)	2.30	(4)	2.30	(5)
Overhead, administration, and maintenance	8.29	(23)	10.67	(19)	11.62	(25)
Total	$35.49		$57.19		$47.18	
Range:	$33-39 (2 sites)		$53-74 (4 sites)		$35-70 (4 sites)	

[a]Figures in parentheses represent percentage of total cost.

chips (chips) or roundwood logs or a combination of both. The decision on which to produce is made ultimately by the logging firm. Close utilization standards (such as a Forest Service requirement to remove all timber that is 2 inches in diameter and larger that is applied to certain salvage sales) generally imply that the logging firm will produce either chips or a combination of roundwood and chips since smaller material is suitable only for chipping.

The first question in this study was whether there is any clear economic advantage in harvesting either a combination of roundwood and chips or only chips in small, dead timber. A major finding based on the demonstration harvest was that the costs of harvesting both roundwood and chips ranged higher and were more variable than the cost of harvesting only chips (Table 1). In the 1979 demonstration harvest, when only chips were produced, the delivered cost of chips was $33 to $39 (avg. $35.49) per ovendry ton. When roundwood was produced in combination with chips, delivered cost of roundwood logs was $53 to $74 (avg. $57.19) per ovendry ton, while the cost of chips was $35 to $70 (avg. $47.18) per ovendry ton.

However, it was also found that local market prices are different for roundwood and chips and that prices vary over time. With such varying prices, and despite differences in harvest costs, at times it may be more profitable to produce a combination of roundwood and chips while at other times, more profitable to produce only chips. The previous observations may seem rather obvious but they are important in considering the use of dead timber for fuel, as will be discussed.

Several things undoubtedly contribute to the higher and more variable costs for combined production of roundwood and chips. Small, dead softwood typically has many stems per acre but stem size and quality are variable. Sorting and trimming of roundwood logs is time consuming, costly, and variable because many small stems are sorted and trimmed but volume per stem is small and variable. Efficient production of roundwood logs requires costly equipment, such as a log loader and log trimmer, that are not required when only whole-tree chips are produced. Chip costs are also higher when produced in combination with roundwood because of delays connected with sorting of roundwood and because smaller stems are chipped when larger roundwood logs are sorted and recovered.

However, cost is not the only factor involved in harvesting decisions. Prices are also important. If harvesting decisions are made on a weekly or daily basis, changes in prices can quickly result in changes in product output. Furthermore, the markets for roundwood and chips from dead timber are different and highly variable over time.

For example, in 1979 and 1980 there was a general slowdown in the economy and a dramatic decline in new home construction. The price history of lodgepole pine Stud grade lumber (Fig. 3) clearly reflects the economic slowdown which has continued into 1982. As demand and price of lumber and other roundwood products declined through 1980 and 1981, demand for the marginal quality roundwood logs from small, dead lodgepole declined even more dramatically. In 1979, when demand for roundwood logs was still fairly strong, log buyers paid $50 to $80 per ton for small roundwood logs from dead lodgepole pine. However, as lumber production declined during 1980, some log buyers literally went out of business. By 1981, the market for dead lodgepole pine roundwood almost disappeared. During the same period, in 1979, the market price for whole-tree chips was only about $20 to $35 per ton. In 1980, mill residues became scarce as lumber production declined and chip prices soared. In the eastern Oregon area chip prices increased to around $80 to $90 per ton.

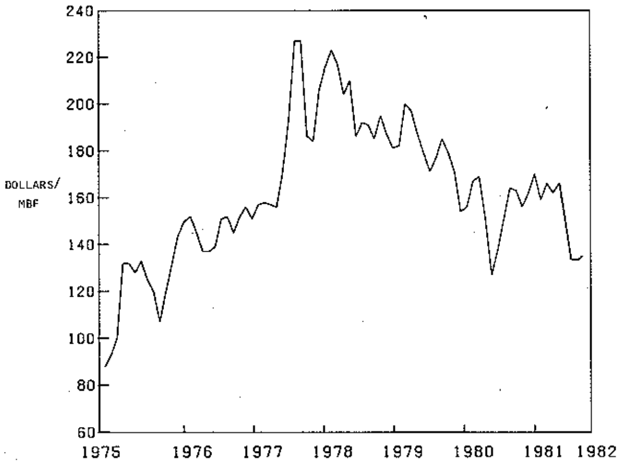

Figure 3. — Monthly average prices of lodgepole pine Stud grade lumber.

When market prices were considered, it was apparent that production of roundwood in combination with chips could have been more profitable than production of only chips in 1979. By late 1980 and 1981, it was clearly more profitable to produce only chips rather than a combination of roundwood and chips. Furthermore, this situation is probably transitory. There is no reason to believe roundwood prices will not rise again if log demand increases or chip prices will not decrease. In fact, chip prices subsided considerably since 1980 to a level of $45 to $60 per ton in early 1982.

The obvious result of this analysis was that market prices as well as costs determine the combination of products that are produced most profitably from small, dead timber. The cost of producing only chips in this study ranged lower and was less variable than the cost of producing a combination of roundwood and chips. However, it is not possible to say that one product recovery option will be more economical based only on costs (even in the short run) because market prices are highly variable. That result is likely to be true for small, dead timber in other regions outside of eastern Oregon also, except generally raw material prices vary more in the Western United States than in the Eastern United States, so prices are likely to be a bigger factor in the West.

Problems in utilization

A second question in this study was whether small, dead timber is acceptable for primary products. Physical properties of small, dead timber can present utilization problems. Blue stain, checks, dryness of the wood, decay, and small size can make production and marketing of certain products difficult. However, various reports indicate that good product recovery can be obtained from small, dead timber (1, 4-11). A conclusive observation made in this study was that a consensus does not exist among local processors about the quality and utility of small, dead lodgepole pine.

Managers of several dozen different mills were interviewed during this study. Some were firmly opposed to using dead lodgepole pine. Others seemed to go out of their way to obtain it and actually found advantages with small, dead timber. Many log home manufacturers, for example, preferred dead lodgepole pine because dead wood is dry and does not shrink like green wood. Many sawmills obtained adequate lumber recovery from small, dead lodgepole pine and apparently profited from the relatively low cost of raw material (so long as there was adequate market demand for lumber). One sawmill completely eliminated the need for dry kilns by utilizing only dry, dead lodgepole pine; lumber was cut from dead timber and sold as "air dried." Small, dead softwood is also suitable and used for a variety of other products including fenceposts, corral poles, mine timbers, and various treated wood products.

Small, dead timber may not be the most desirable raw material, depending on product, but if other sources of timber are limited and there is good product demand, it can certainly be used and is acceptable for primary products despite undesirable physical properties. Since dead timber deteriorates with time, it is of course best to schedule a harvest as soon as possible after mortality in order to reduce defects and utilization problems.

Problems in harvesting

The third question in this study was whether physical properties of small, dead timber would create major problems in harvesting. It was found that physical properties of small, dead lodgepole in Oregon do not create major problems in harvesting. Physical properties of the wood including dryness and other defects caused only minor problems in harvesting. Chipper blades required approximately twice the maintenance relative to what would be required with green timber. Also, reduced weight of dry, dead wood resulted in transport vehicles not always being loaded to full weight capacity. On the other hand, dryness of dead wood could permit a larger volume to be transported per load than with green wood if vehicles were designed to accommodate the larger volume. The large number of small stems probably reduced harvesting efficiency also; however, the large number of stems allowed for a product recovery of 32 tons per acre. In general, physical properties of the timber did not cause prohibitive problems in harvesting.

The climate throughout much of the Western United States is rather dry so wood decays slowly and most small, dead timber remains standing for many years. Harvesting dead timber with a rubber-tired feller buncher and skidder type harvesting system (which is probably the most efficient system for harvesting small, dead timber) is much less difficult if the timber is standing than if it has fallen. Again, the distribution of wood moisture content illustrates the dryness of dead lodgepole pine in the Oregon study (Fig. 2). In other regions with higher humidity conditions and higher wood moisture content, dead timber would decay more rapidly. In such areas, decay could cause timber to blow down or collapse prior to harvesting, creating extremely difficult operating conditions for conventional equipment. Again, since stands of dead timber deteriorate with age, it is best to schedule a harvest as soon as possible after mortality in order to reduce problems with blowdown and stand deterioration.

TABLE 2. — *Average energy inputs and outputs (as fuel) per ovendry ton of chips derived in this study.*

Gross inputs		Output	
(Energy values in million Btu per ovendry ton)			
Felling and bunching	0.14	Gross	19.0
Skidding	.12	Recoverable	12.5
Chipping	.18		
Miscellaneous operations	.22		
Transportation	.17		
Total	0.83		

Beetle-killed timber as fuel

Finally, there were the questions: is small, dead timber an energy efficient fuel and an economical fuel? It was found that small, dead lodgepole could certainly be an energy efficient fuel, but whether it would be economical is still questionable.

An average energy balance per ovendry ton of harvested and delivered chips was derived from data obtained in the demonstration harvest (Table 2). It was found that energy inputs to the harvest operations — felling and bunching, skidding, chipping, miscellaneous operations, and transportation — represented a total of about 830,000 Btu's per ovendry ton of chips on the average, delivered about 50 miles from harvest sites. The inputs include direct energy inputs, particularly the fuel required to operate the equipment during harvesting and transporting the chips, and also an estimate of the indirect energy input to manufacture the equipment. Various other energy inputs such as energy input to provide roads, public services, or land management activities are not included. In comparison, recoverable heat energy in dead lodgepole chips (at 20% moisture content) if used as fuel, is approximately 12.5 million Btu's per ovendry ton. Energy inputs in harvesting and delivery were, therefore, found to be only about 6 to 7 percent of the recoverable heat energy if the wood is used as fuel.

Based on this study, small, dead timber is an energy efficient fuel. However, energy efficiency does not necessarily imply that small, dead timber is an economical fuel. Energy efficiency and economic efficiency are different criteria. The final focus of this study was on whether small, dead timber could be an economical fuel. The results are not conclusive.

In 1979, it was found that chips could be produced at a cost of around $35 per ovendry ton. After adjusting for inflation, the cost in 1982 would probably be about $45 to $50 per ton. Since dead lodgepole pine has an estimated recoverable heat energy of 12.5 million Btu's per ton, it has a 1982 energy cost of about $3.60 to $4 per million Btu's of recoverable heat energy. How does that compare with other types of fuels?

At $1 per gallon, fuel oil is priced at over $8 per million Btu's of recoverable heat energy. At $4 per thousand cubic feet, natural gas is priced at about $5.25 per million Btu's. At $60 to $80 per ton, coal is priced at $3 to $4 per million Btu's. This comparison does not consider the cost of combustion systems which are generally more costly for wood and coal than oil or gas.

On the basis of cost of chips in comparison with prices of other fuels, it appears that small, dead timber could be an economical fuel in some circumstances (as a substitute for oil or gas, provided there are economical combustion systems). However, as already pointed out, cost is not the only factor that determines which products are produced from small, dead timber. Market prices are also important. The independent logging firm adjusts product output in response to market prices and demand in the short run. Therefore, the use of dead wood for fuel competes with other product end uses. When chips were sold in the market for $90 per ton for pulpwood in 1980, they had an implicit energy price of $7 to $8 per million Btu's as fuel, which was about the same as oil.

Development of any large energy facility for using dead timber as fuel requires long-range plans, including plans for supply and price of fuel. Short run behavior of independent logging firms in response to market demand and prices for other products might upset such long-range supply plans. One suggestion is to install energy facilities that are capable of burning an alternate fuel in addition to dead timber. That way some advantage could be obtained when dead wood chips are available as fuel at low prices while the alternate fuel could be used at other times.

Summary

Small, dead timber can be used for a variety of products. Different products compete in price for small, dead timber despite the fact that the resource is abundant. Logging firms can change product output in the short run, among various products, from roundwood to chips. The point to recognize is that the commercial motivation for harvesting small, dead timber is profit margin which depends on the market prices of various products. Consequently, a fundamental recommendation for forest products research (if it is to promote better use of dead timber) is to continue developing higher value products for small, dead timber.

The use of dead timber for low value products, such as fuel, is praiseworthy from a silvicultural standpoint because it is aimed at removing dead timber from the forest. However, there is no greater motivating factor for harvesting small, dead timber than profits induced by increasing its value as raw material. In considering utilization research and the problem of small, dead timber, creative research must continue to be focussed on developing products which contribute higher value and prices to small, dead timber as raw material. Development of higher value products could ensure that the large available quantities of small, dead timber become profitable to harvest.

In summary, in regard to small, dead timber as represented by dead lodgepole pine in eastern Oregon, the findings were:

1. The cost of producing only whole-tree chips ranged lower and was less variable than the cost of producing a combination of roundwood and chips per unit weight of product.

2. Market prices vary over time so, despite the difference in costs, at times it may be profitable to produce a combination of roundwood and chips, at other times only chips.

3. Small, dead timber is harvested in accessible terrain with conventional equipment without major or prohibitive problems. Furthermore, despite some undesirable physical properties, it is utilized for various products when there is sufficient demand for those products.

4. In regard to using small, dead timber as fuel, the recoverable heat energy is about 15 times the energy required to harvest and transport it (50 miles from harvest site).

5. Whole-tree chips from small, dead timber can be harvested and delivered as fuel at a relatively lower cost-to-energy-ratio than the price-to-energy-ratio of oil or gas, but apparently not coal. However, the price-to-energy-ratio for dead lodgepole chips is likely to be higher and more variable than the cost ratio, owing to alternative and competing end uses and variable market prices.

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Cooperative research results in patent on blender unit

A patent on a blender which reduces the cost of adhesives in the production of particleboard has been issued to two Washington State University scientists and the WSU Research Foundation.

Thomas M. Maloney and E. Max Huffaker, working with researchers at the U.S. Forest Products Laboratory (FPL) in Madison, Wis., invented the equipment for better blending of adhesives and other additives with wood particles before they are pressed into construction boards.

The prototype blender unit was constructed and tested in the WSU Wood Technology Laboratory. The system, which will be custom-built for each plant, is made up of cylindrical components. Wood particles are fed into the top of the system and as they spin down through the column adhesives, other chemicals are introduced.

Maloney, director of the WSU laboratory and past president of the FPRS, says the system has the potential of saving the American particleboard industry $24 million a year.

An agreement has been reached with the Emerald Manufacturing Co. of Grundy Center, Iowa, for commercial development of the equipment.

The research foundation will receive royalties for the rights to produce the equipment and a share of the proceeds from future sales. Maloney and Huffaker receive a small percentage of the foundation's receipts from the agreement.

Maloney said several foreign patents are also being applied for.

The WSU laboratory has pioneered many of the developments in particleboard production and sponsors an annual international meeting in Pullman which attracts scientists and producers from throughout the world.

Maloney said several years of cooperative research with the Madison lab have gone into the blender concept.

"Cooperative research projects of this type are excellent ways to marshal research expertise for the solution of problems," Maloney said. "Both laboratories participating in this blender research were able to contribute the experience and technical expertise of several scientists. Thus a team of researchers was assembled which could accomplish things that neither laboratory could do on its own."

John Youngquist, project leader of the Structural Composite Products research work unit at the FPL, said, "Because the blender was developed as a result of a cooperative agreement between U.S. Forest Products Laboratory and Washington State University, it was possible for the FPL to assign the rights to this piece of equipment to WSU. They can, in turn, franchise these rights to interested firms to bring the invention to the point of practical application.

"This arrangement provides a technique whereby an incentive can be offered to an interested equipment manufacturer which will allow for the recovery of some of the development costs incurred in moving a laboratory invention, like the blender, through the various equipment scale-up activities and into production operation.

"This project provides a good example of how federal and state financed laboratories can work together to conserve and extend the supply of some of our costly, nonrenewable resources, while still providing incentives for the transfer and successful implementation of this technology." ■