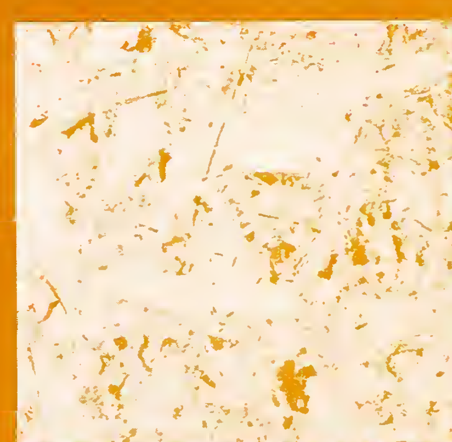
The Outlook for Particleboard Manufacture in the Northern Rocky Mountain Region



USDA Forest Service
General Technical
Report INT-21, 1975

INTERMOUNTAIN FOREST
AND RANGE
EXPERIMENT STATION
Ogden, Utah 84401

USDA Forest Service
General Technical Report INT-21
June 1975

THE OUTLOOK FOR PARTICLEBOARD MANUFACTURE IN THE NORTHERN ROCKY MOUNTAIN REGION

Richard Withycombe

This report was prepared as a cooperative project of the Intermountain Forest and Range Experiment Station and the Bureau of Business and Economic Research, University of Montana, Missoula.

INTERMOUNTAIN FOREST AND RANGE EXPERIMENT STATION
Forest Service
U.S. Department of Agriculture
Ogden, Utah 84401
Roger R. Bay, Director

THE AUTHOR

RICHARD P. WITHYCOMBE is Assistant Professor of Management and Research Associate of the Bureau of Business and Economic Research, School of Business Administration, University of Montana, Missoula.

ACKNOWLEDGMENTS

The author is grateful to the many individuals, agencies, and businesses who helped prepare this study. Because so many contributed, none will be acknowledged by name. Special thanks go to those particleboard manufacturers and engineering consultants who provided data on their own plant operations.

CONTENTS

ABSTRACT

National demands for particleboard panel products and raw materials supply are projected for the 1970's. Demand for particleboard (which includes fiberboard and structural particleboard) is expected to continue rapid growth through the decade. New plant capacity will use dry mill residues wherever possible. Several new plants are expected in the South, and three or four each in California, the Pacific Northwest, and the Northern Rocky Mountains. In the last of the decade, expanding production will turn to use of forest residues, which will shift plant expansion toward the major markets and away from the Northwest. Analysis of production costs indicates that in the Northern Rocky Mountains plants utilizing forest residues cannot profitably compete with plants that utilize mill residues until the existing mill residues are exhausted.

INTRODUCTION

Before attempting to assess the future of particleboard manufacturing in the Northern Rocky Mountain region, we should take a brief look at the history of particleboard. The forces that shaped the growth of the industry are still operating and must be considered when attempting to forecast future developments.

What Is Particleboard?

Surprisingly, particleboard is not easily defined. The Department of Commerce (1973) defines it as:

> ....an engineered product, matformed, consisting of machined fiber particles such as granules, chips, slivers, flakes, shavings, etc., of a controlled moisture content and size, bonded together with a synthetic resin or other added binder into panel form under controlled heat and pressure.

Although this definition is adequate, it does not differentiate particleboard from its close relatives, fiberboard and hardboard. Naming a particular product is quite arbitrary, but in this case it depends primarily on the degree of refinement of the particles and on the density of the finished board. Fiberboard and hardboard tend to use more highly refined and fibrous materials than does particleboard, which may use rather large chips or flakes. The density of the finished board separates fiberboard, at 12 to 31 pounds per cubic foot, from hardboard, at 32 to 70 pounds. Particleboard falls in between, at 35 to 55 pounds.

Although many products fall clearly into one of the three classifications, there is a great deal of overlap. The remainder of this analysis will concentrate on the products generally classed as particleboard, but of necessity will digress at times into products that could more properly be classed as either fiberboard or hardboard.

Development and Growth of the Particleboard Industry

Particleboard has been in use for a long time, but the volume of production was insignificant in relation to other wood products until the last decade. Production (and consumption) began to soar in the late 1950's and early 1960's in Europe, and somewhat later in the United States and Canada.

Although Europe is usually not thought of as a world leader in wood products, there is no question about its leadership in both the technology and production of particleboard. In 1969, European consumption was 8.9 million cubic meters, compared with 3.0 cubic meters for the United States and, although consumption in the United States seems to be growing somewhat faster, Europe still leads in particleboard production. Exports and imports of particleboard are negligible in the United States, but international influence on technology and capital equipment is not. Many of the manufacturing techniques and much of the equipment used in the United States are imported from Europe.

Growth of the particleboard industry in Europe was apparently a response to market demands for an economical wood panel. European supplies of wood, especially those suitable for plywood panels, are limited. Particleboard provides a source of reasonably priced panels that can be made from almost any type of wood (and from some nonwood materials such as sugarcane stalks).

The particleboard industry in the United States has developed for different reasons than it has in Europe. Whereas European growth was pulled along by unfilled demand, the growth in the United States was pushed by the supply of raw materials. Normal sawmill operations produce vast amounts of waste in the form of bark, edgings and trim, sawdust, and planer shavings. For years the usual disposal method was burning, sometimes as fuel, but more often as waste. Pressure against smoke pollution, combined with the economic pressure of increasing wood costs, made the use of these former wastes a necessity.

Papermills were the first to make significant use of the mill wastes. Edgings and trim from sawmills rapidly replaced roundwood as a major source of pulp chips. Particleboard manufacturers soon perfected techniques for utilizing dry planer shavings, which opened up enormous supplies of raw material that were available almost free. Planer shavings appear to be ideal for particleboard; they are relatively dry and are already close to the size and shape desired. After a minimum of drying and milling, done primarily to maintain uniformity rather than to make major changes in the particles, the shavings are ready for use. The cost of purchasing and preparing the shavings is so low that the greatest cost is often transportation of the shavings from the mills where they are produced to the plants where they are used for particleboard.

That material supply, not product demand, was the primary stimulus in the development of the domestic particleboard industry can be inferred from both the pattern of expansion and the history of prices.

The first wave of expansion was in Oregon, which has the greatest concentration of sawmills (and wood waste) in the Nation. Although Oregon is remote from the major markets, the availability of large quantities of cheap, high quality materials favored plant location there. The industry has continued to expand in the Far West; however, during the late sixties the major growth shifted from the West to the South. Rapid expansion of both lumber and plywood production in the southern pine region again created a concentration of mill waste. This time, however, the mill waste was located close to to the wood products market, and the particleboard plants followed close on the heels of the lumber and plywood mills.

In 1972, about 95 percent of the production of particleboard was split evenly between the southern pine States, with no real concentration, and the Far West, mostly in Oregon. As of late 1973, expansion in particleboard capacity, as judged by announcements of new plants in the trade journals, appears to have slackened from its enormous growth of the past few years, when capacity more than doubled between 1968 and 1972.

The supply-push on particleboard production can also be inferred from the price of particleboard during this rapid expansion period. Like other wood products, the price of particleboard is quite volatile, but even so, particleboard prices have remained more constant over the last few years than have prices for similar and competing products such as plywood.

In January 1968, the price of 1/2-inch exterior plywood stood at $74 (per 1,000 feet); it then rose rapidly to a peak of $142 in February 1969, fell back to $74 in March 1970, rose again to a peak of $180 in March 1973, and since then has fallen again.

Particleboard prices had a similar peak and fall in 1969, but rose very little during the next 3 years (fig. 1 and 2). Although 1/2-inch exterior plywood and underlayment particleboard are not directly competing products, both are used primarily in housing construction, and so should have similar demand forces on their prices. The stable or slightly falling prices for particleboard during a long period of rising plywood prices indicate that the supply of particleboard was growing faster than the demand.

In the analysis that follows, we will first investigate the national markets for particleboard and the possible future changes in the market structure. Next we will examine the expected patterns of expansion in production capacity. We have already noted that the early expansion of the industry was geographically concentrated first in Oregon and then in the southern pine region. In assessing the manufacturing potential in any one area (such as the Northern Rocky Mountains), we cannot ignore the trends in the rest of the country. In the final portion of this analysis, we will examine the cost of particleboard manufacturing in the Northern Rocky Mountain area, with emphasis on those cost factors which would place this region at an advantage or disadvantage in comparison with other possible locations.

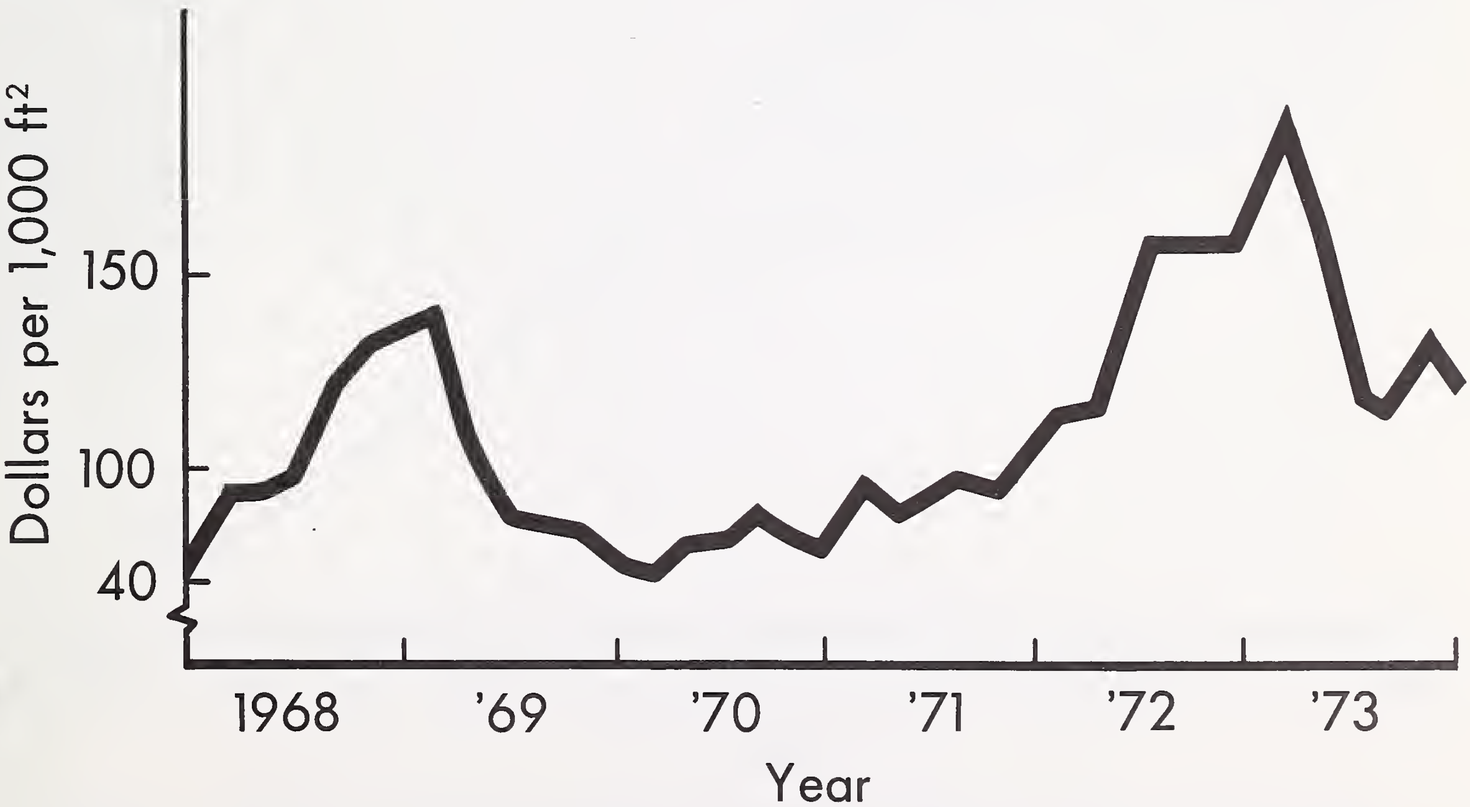


Figure 1.--Plywood prices; 1/2-inch CDX, f.o.b. west coast. Source: Crows Plywood Newsletter 1968-1973

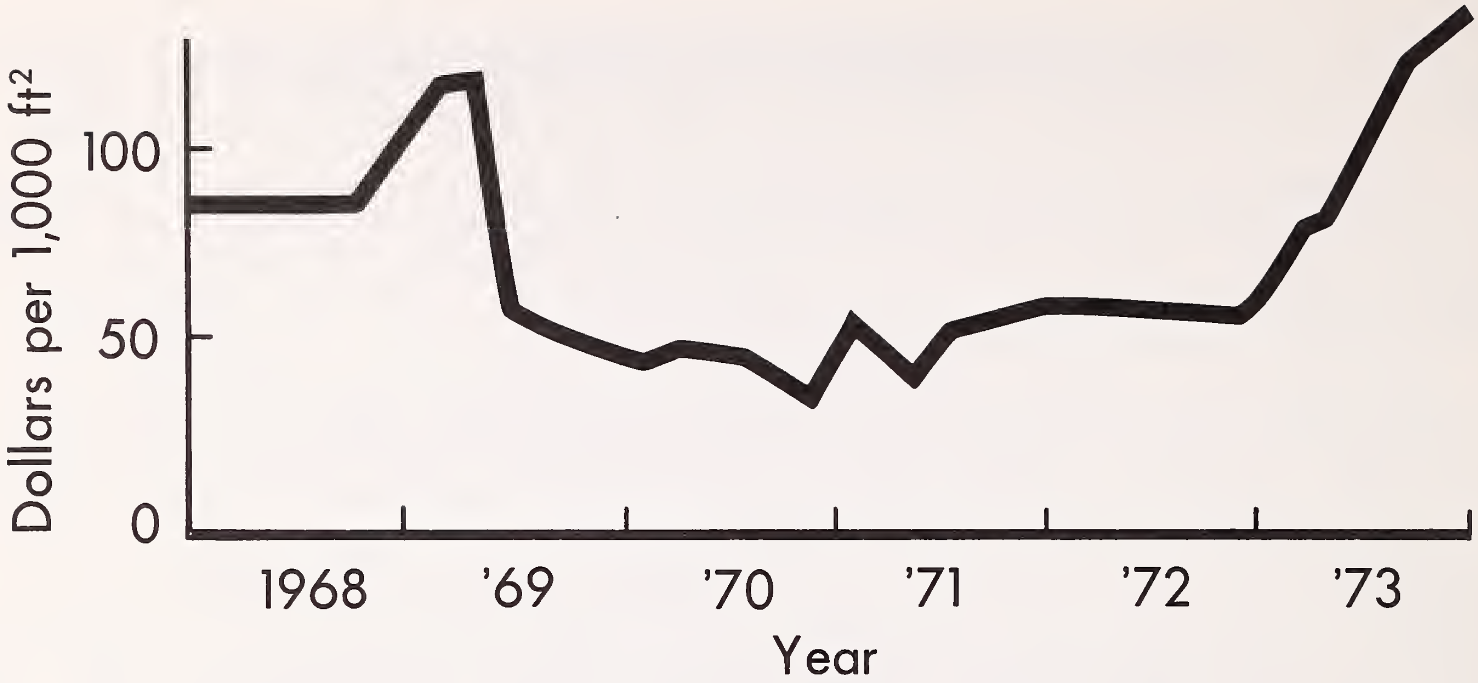


Figure 2.--Particleboard prices; 5/8-inch underlayment, f.o.b. west coast. Source: Crows Plywood Newsletter 1968-1973.

PARTICLEBOARD MARKETS

The nationwide demand for particleboard has grown rapidly in the past decade, and all indications are that it will continue to grow for some time in the future. The real questions to be answered are how much increase might be expected, and what changes there might be in the product mix or geographical distribution of the demand.

The total production of matformed particleboard is shown in figure 3, along with several possible projections through 1985. Figure 3 shows the quantity of production, not the actual demand for particleboard. Although the two are closely related they are not the same, and it is demand, not production, that we want to forecast. If demand for

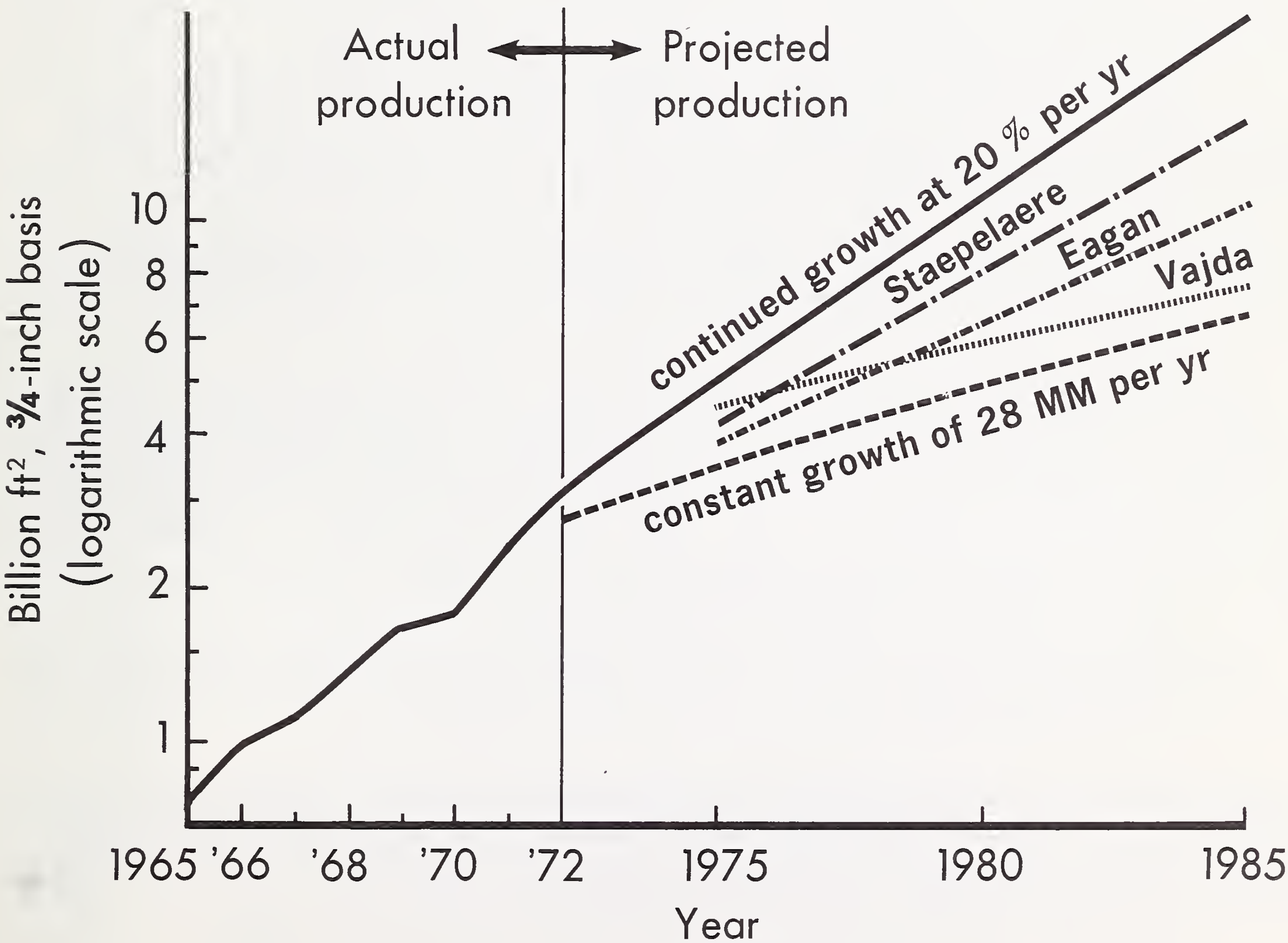


Figure 3.--Actual and projected particleboard production in the United States. Actual production source: U.S. Department of Commerce 1973.

a product is less than production during any time period, the surplus will accumulate as inventory, either at the site of manufacture or in the distribution channels. Particleboard, however, is bulky and requires covered storage, so that neither the manufacturer nor the distributor is likely to attempt to accumulate much. When demand slips below production capacity, the production is restricted, so that the two are equal.

If the demand is greater than the production capacity, the effects are more subtle and difficult to measure. The excess demand can disappear by being shifted to alternate products, or it may appear as an increase in backlogged orders to the manufacturer. Data are not available to estimate either effect. If there was excess demand, however, there should be pressures for increased prices. The stable prices for particleboard over the past 7 years indicate that demand has not significantly exceeded production, so that we may safely use actual production as a good indicator of the demand.

Forecasts of Future Demand

Of the many techniques for forecasting product demand, the most usual is simply to extend the observed patterns of the past into the future. Two lines are shown on figure 3; each is an extension into the future based on different assumptions about the nature of the growth pattern.

The upper line (solid) is determined by finding the average percentage increase each year and extending it into the future. From a volume of about 800 million ft^2 (3/4-inch basis) in 1965, production has increased to 3.2 billion ft^2 in 1972, an average increase of 20.8 percent per year. Extending this rate of increase gives a forecast of 5.28 billion ft^2 in 1975 and 13.6 billion ft^2 in 1980.

The lower line (dashed) projects the average amount of growth as obtained by linear regression. The average growth from 1965 to 1972 was 28 million ft^2 per year; extending this constant growth into the future yields a forecast of 3.5 billion ft^2 in 1975 and 5 billion ft^2 in 1980.

Both of these forecasting techniques are reasonable and are widely used, but in this case yield quite different forecasts. A difference between 5 and 13.6 billion ft^2 for 1980 cannot be passed over lightly. Which of the techniques is more likely to be correct depends on where particleboard is in the growth cycle.

Most products progress through a demand pattern similar to that shown in figure 4. A period of slow growth is followed by a period of rapid expansion, when the amount of growth increases each year. At some point the curvature of the growth pattern shifts, and although growth continues, it does so at an ever-decreasing rate. The period of time between introduction and maturity is highly variable, but seems to depend primarily on how specialized the product is. Very highly specialized products such as color television may go from introduction to maturity in a few years, but general-use products such as electrical energy may take many decades.

During the rapid-growth phase, a forecast based on a constant-percentage growth can be expected to give accurate results. During the maturity phase the constant growth rate will yield a better forecast.

Particleboard has obviously passed the introduction phase and is well into the rapid growth phase, so the percentage growth forecast is the more reasonable, at least for the very short term. Rapid growth must end eventually, however, and the immediate question is how close is particleboard to its maturity. There is no way to tell except for expert opinion, which may be subject to considerable error.

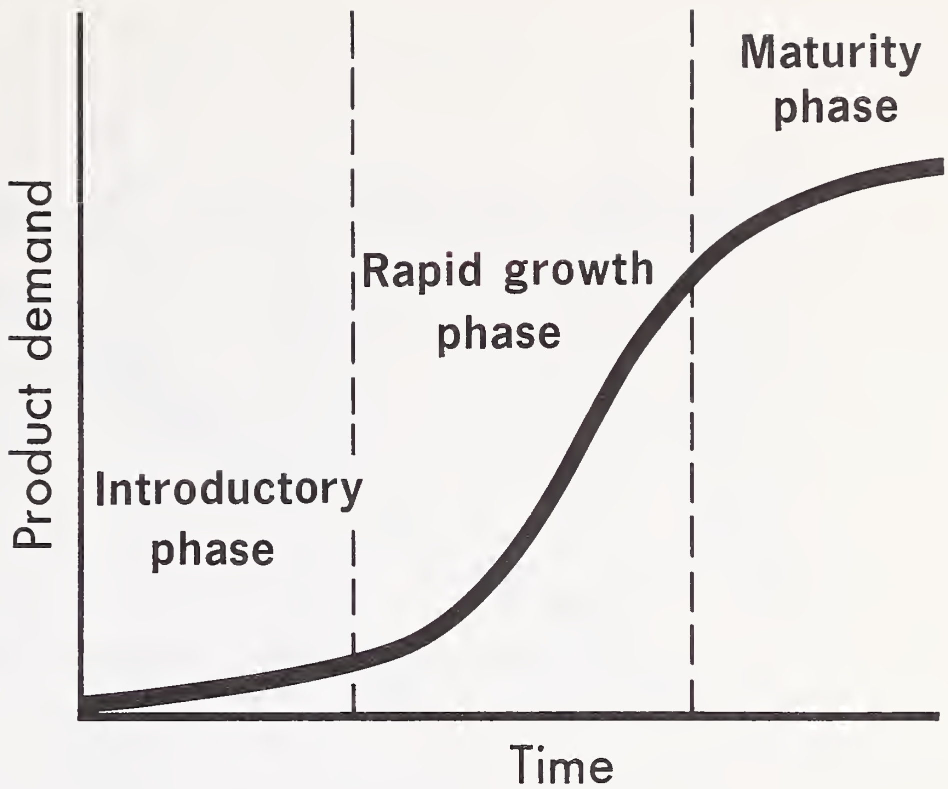


Figure 4.--Typical product life cycle.

The period of rapid growth for any product can be prolonged by the development of large new markets. When growth for the product depends on growth in the market already served, the rate of growth decreases and maturity is achieved.

Within the past decade many new particleboard markets have opened, hence the rapid growth. The most important of the new markets have been floor underlayment in residence construction, core stock for furniture, and decking for mobile homes. A recent development has been painted or decorated panels for interior walls, cabinets, and furniture. If the particleboard industry must look only to these established markets, then growth will be limited, probably to the level shown by the dashed line on figure 3.

A number of potential new markets for particleboard are just now being entered or are in the early speculation stage. Finished panels that are painted, embossed, or overlaid with a vinyl or wood veneer are already being produced in quantity, but are probably just starting into the rapid growth era. Of lesser magnitude is precut and edge-finished shelving. First made to convert damaged panels into a salable product, shelving found quick acceptance and a ready market, and is now being produced as a primary product.

Still in the early introduction stage is structural particleboard, which is intended to replace plywood sheathing in subfloors, walls, and roofs. Most particleboard is produced to provide uniform, smooth surfaces and good machinability. Structural boards are designed for strength by using larger flake-type particles and for moisture resistance by using phenolic bonding agents rather than the usual urea resin.

Structural boards have the potential for markets much larger than any of the current uses of particleboard, but it is still too early to predict how large the market might be or how soon it will become a major component of the total market. A structural board is being produced in Canada under the brand name "Aspenite," and a similar plant to produce a similar board is under construction in the United States. A rapid expansion of structural board production cannot come until the design of the board and the techniques of manufacture are more firmly established and the product is accepted for use under the various building codes which govern the use of structural materials. Work is well underway on both problems, but neither is near solution.

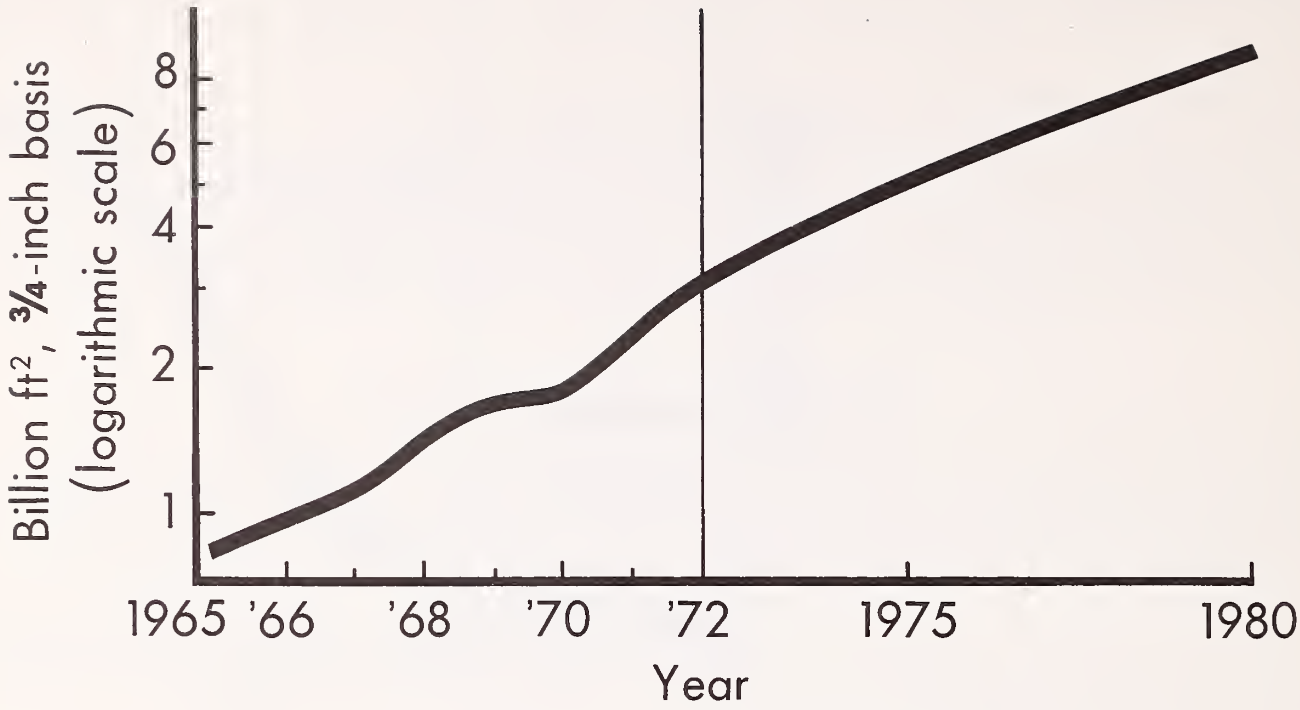


Figure 5.--Forecast of particleboard demand in the United States.

Structural board will probably not have a significant effect on the total particleboard market for several years, but its introduction may be speeded up by short supplies and rising costs of plywood.

Potential products now being researched include thick panels for roof decking, corrugated panels, and particleboard-wood veneer combinations. The trade journals fairly burst with ideas for new products and new market potentials, and it appears that particleboard is not yet close to market maturity. We can expect that the pattern of growth through the 1970's will continue at a high percentage growth rate.

Forecasting is so dependent on personal judgment that it is always comforting to find that others have arrived independently at about the same results. Figure 3 shows actual particleboard production in the United States through 1972 and projects production through 1985. Two projections were developed for this study--an upper projection based on growth continuing at 20 percent per year, and a lower projection based on constant growth of 28 million ft^2 per year. In addition, projections from three other sources are plotted: Vajda (1970) of Columbia Engineering, a consulting firm; Staepelaere (1971) for Black-Clawson, manufacturer of particleboard-producing machinery; and Eagan (unpublished), Colorado State University, and the Rocky Mountain Forest and Range Experiment Station. The latter forecast was developed separately for the many end uses of particleboard, such as furniture, mobile homes, and so on, and was tied to projected increases (1947-1970 data base) in population and gross national product.

Although none of these forecasts are identical, they are in close agreement considering the uncertainties involved in projecting the demand for any rapidly growing product so far into the future. All three of the forecasts shown were made before the actual demands for 1971 and 1972 were known.

The forecast of total particleboard demand shown in figure 5 will be used throughout the remainder of this analysis. It combines published forecasts and the maximum expected growth from figure 3; and like all forecasts it is, in the end, based primarily on individual judgment.

Actual demand (billion ft^2)		Forecast demand (billion ft^2)	
1965	0.8	1973	3.6
1966	1.0	1974	4.2
1967	1.115	1975	4.8
1968	1.425	1976	5.5
1969	1.700	1977	6.4
1970	1.760	1978	7.2
1971	2.460	1979	8.0
1972	3.120	1980	9.0

Figure 5.--(con.)

Regional Distribution of Markets

Data are not available on the regional distribution of particleboard markets, but some published estimates are available which provide a sufficient breakdown for the present purposes. Vajda (1970) has estimated the following regional distribution for 1970, based on analysis of mill shipments:

Region	*Percentage of total market* (*Percent*)
South	37
North Central	25
Northeast	18
West	20

Richard Bruce (1970) estimated the regional markets for particleboard by relating it to the demand for plywood (for which data are available). This method gives identical results for the two Northern regions, but indicated 32 percent for the West and 25 percent for the South. Relating particleboard to plywood tends to ignore the effects of the furniture industry, which is a heavy user of particleboard but not of plywood, and which is very concentrated in the Southern States. For that reason, Vajda's regional breakdown will be used.

There are, of course, market concentrations within these broad geographic regions, generally within the major metropolitan areas. Bruce estimates concentrations of 13 percent (out of 25 percent for the whole North Central region) in the Chicago-Milwaukee area, and 16 percent (out of 18 percent for the Northeast) concentrated in the Boston-Washington coastal strip.

Some small changes in the regional distribution have been projected by Vajda, but in view of the uncertainty about the level of the total market, they are of minor importance. Growth caused by expansion of existing markets can be expected to maintain the same geographical distribution as we now have. The opening of new markets such as for structural board may change the distribution somewhat, but we can expect that over the next 5 to 10 years the changes will be minimal.

Product Differentiation Within the Particleboard Market

Although it is easily recognized that not all particleboard is the same, there is considerable uncertainty as to how many different varieties exist.

The Commercial Standard CS 236-66 (U.S. Department of Commerce 1966) lists 10 types of board. Boards are classed by type of binder (two types), density (three grades) and strength (two classes). In reporting production statistics, however, the Department of Commerce, of which the Bureau of Standards is a part, lists only two types: floor underlayment, and other. The picture one gets from the trade journals is that there are as many types as there are manufacturers. There is, obviously, some product differentiation.

The Department of Commerce practice of reporting only two product categories appears to be sufficient for the present. The "underlayment" category actually includes all boards reported by manufacturers as going to nonindustrial buyers. It consists primarily of urea resin-bonded (interior use only), medium density (37-50 pounds) boards of class 1 strength (low strength), in normal 4- by 8-foot panel sizes. Underlayment is a general, commodity-type product. It is not easy to distinguish one producer's board from another, and most users probably don't care what it is or where it came from, so long as it meets minimum standards. Price and availability are the most important attributes for this type of product. Much of this type of board ends up in applications such as cabinets and shelves, but its major use is as a floor underlayment. In 1972, 30 percent of the total production was classed as underlayment.

The "other" category of the Department of Commerce is usually referred to as industrial board, and is quite differentiated compared to underlayment. In general, industrial board is higher quality than underlayment, where the definition of quality changes from user to user. Usually, smoother surfaces and edges and easy machinability are the desired characteristics. At times, strength, screw-holding ability, and appearance are important. In addition to physical differences, industrial board has no standard sizes, and is produced in a wide variety of thicknesses and panel sizes. There is a strong trend toward surface finishing at the plant, which may include painting, embossing, and overlayment with vinyl or wood veneer.

Much of the product differentiation in the industrial market is superficial; the basic product is much the same but is changed slightly by modifying the density or the finished size to suit the customer's needs. The end effect, however, is that the industrial board market has no real standards, in either the product or the price.

Structural particleboard will warrant a classification of its own as soon as production becomes significant. Structural board, like underlayment, will be a standardized product used primarily in housing construction. The requirement for a standardized product that will be imposed by the building codes will make product differentiation among manufacturers difficult, although several types of board may eventually be lumped together in the general category of structural board.

OUTLOOK FOR PRODUCTION

The demand for particleboard, and its production, will increase substantially over the next few years. The current production of a little over 3 billion ft^2, 3/4-inch basis, was produced by 62 plants, at an average output of 48 million ft^2 per plant. Increases over the next 2 years can come only from new plants already started or from increased capacity at existing mills. An unpublished survey by Columbia Engineering International, Ltd., Vancouver, B.C., of new plants and expansions already underway shows a total of 15 new plants that will be producing an additional 1.3 billion ft^2 by 1974. This is an average output of about 85 million ft^2 per new plant, a substantial increase over the present size; a trend that can be expected to continue. If production is to continue to expand to 5.5 billion ft^2 in 1976 and 7.2 billion ft^2 in 1978, we will see an additional 12 to 14 plants under construction in 1974-1975 and 16 or 17 in 1976-1977 (at an average production capacity of about 100 million ft^2 per plant).

The new plants will be located wherever they will obtain the greatest economic advantages, which will depend primarily on the type of product, the location of markets, and the availability and price of raw materials. Some insights into the expected expansion can be gained by examining the patterns of past expansions and the forces that have governed the growth of the industry.

Past Growth Patterns

In its early stages, the particleboard industry relied heavily on techniques and processes developed in Europe for producing boards from specially prepared chips and flakes. During the late 1950's and early 1960's, processes were developed in Oregon to make particleboard from dry Douglas-fir planer shavings. The shavings board quickly became the industry standard and firmly established the west coast as the center of particleboard production. In 1965 about two-thirds of the nation's particleboard was produced in the West, mostly in a small area of western Oregon. The main reason for this concentration, which is about as far from the markets as is possible, was the enormous amount of shavings produced in the Oregon sawmills. These shavings were cheap and required very little processing before being formed into boards. The very low operating costs gained by using shavings more than offset the cost of the long haul to markets.

The rapid growth of lumber and plywood production in the southern pine States created supplies of mill wastes similar to those of the West, but located much closer to the major markets. The particleboard industry was quick to take advantage of the situation, and much of the growth since 1965 has occurred in the Southern States.

Production in the West has continued to expand, but at a much slower rate than in the South. By 1972, total capacity was about the same in the South and the West; together they produced 95 percent of particleboard. Seventy-two percent of the production in the South comes from mills constructed since 1965, but only 39 percent of the West's production is coming from the newer mills.

The pattern of faster growth in the South seems to be continuing. Of the increased capacity now under construction, 410 million ft^2 is in the West (four plants or expansions), and 870 is in the South (four plants or expansions).

The pattern of plant location around supplies of raw materials in the form of dry softwood mill waste can be expected to continue, and with the major markets remaining in the East and South, the South will continue to have a freight advantage and so see the greater growth. Depletion of easily accessible mill wastes in any area, however, may change the pattern of growth, as will any technological shift away from planer shavings.

Availability of Mill Wastes and Projected Expansion

The volume of mill waste materials produced and used in the United States is not known, but a number of estimates are available. Table 1 shows the unused portion of fine softwood mill wastes in the United States in 1970 as estimated in "The Outlook for Timber in the United States," (USDA Forest Service 1973). The techniques were not given, but the estimated unused waste corresponds with detailed studies made in Oregon and Washington in 1968 (Bergvall and Gedney 1970; Manock and others 1970). "Fine residues" includes both sawdust and shavings, both of which are usable furnish for particleboard production.

Not all mill wastes will be available for particleboard manufacture. Some of the waste is generated in small scattered mills which are either remote or have no facilities for waste collection. Production figures by mill size as reported in the annual lumber survey (Lambert 1973) conducted by *Forest Industries* were used to estimate the proportion of the total waste that is produced in small mills and would probably not be collected. There is a significant difference between the West and the South in the distribution of mill size. In the West, 90 percent of the lumber was produced in mills

Table 1.--*Estimated supplies of fine softwood mill wastes available for particleboard, 1970 and 1980*

Area	(1) Unused fine[1] residues from lumber and plywood, 1970	(2) From mills with over 25 million ft^2 capacity	(3) Estimated as available for board manufacturing, 1970	(4) Estimated increase or decrease, 1970-1980	(5) Unused waste available for board manufacturing	(6)	(7) Number of plants, 1980, at 100 million ft^2 per plant
	1,000 ft^3	*Percent*	*Percent*	*Percent*	*1,000 ft^3*	*million ft^2(3/4")*	
South	117,580	64	50	+20	45,150	452	4.5
Pacific Northwest							
Douglas Fir	57,883	90	50	- 8	23,964	240	2.4
Pacific Northwest							
Ponderosa Pine	23,686	90	50	- 8	9,806	98	1.0
California	83,298	90	50	- 8	34,485	345	3.5
North Rocky Mountain	60,187	90	50	+ 6	28,709	288	2.9
South Rocky Mountain	30,711	90	50	+ 6	14,649	146	1.5
Total						1,569	15.8

Sources:

Column 1: USDA Forest Service 1973.
Column 2: Lambert 1973
Column 4: USDA Forest Service 1973.

[1]Fine mill wastes are sawdust and planer shavings from primary processing plants.

having an annual output of 25 million bd. ft. or more (60 percent of the mills). In the South, only 64 percent of the production was from the larger mills (29 percent of the mills). The total unused residues have been multiplied by these percentages, on the assumption that wastes from the smaller mills would be unavailable.

Not all of the available wood wastes will be used for board manufacture; some will be diverted to other uses. The paper industry has been using increasing amounts of mill wastes and we can expect to see that trend continue. Until recently, pulp manufacturers have used only coarse residues such as slabs and edgings that could be processed into pulp chips, and board manufacturers used only the dry shavings. Nobody used sawdust. Recently, both pulp and board manufacturers have found that sawdust can be used in their products and both are now using it. Supplies still exceed demand, but there already are regional shortages of mill waste.

The use of mill residues for fuel can also be expected to rise. Much of the mill residue now burned as fuel contains bark and dirt and is not acceptable as furnish for manufactured products. As traditional fuels such as oil and gas become more expensive and harder to obtain we will see a strong demand for wood residues for fuel.

Alternate uses of fine residues are expected to consume about half of the currently unused residues, with half being available for board manufacturing. (This estimate of 50 percent is strictly a guess.)

Column 4 of table 1 shows the expected increase or decrease in sawmill production over the next decade. Any change in the basic industries of lumber and plywood will have a similar effect on the volumes of residues produced.

Column 5 of table 1 is the estimated fine softwood wastes that will be available for particleboard manufacturers, in thousands of cubic feet. This is converted in columns 6 and 7 into the potential particleboard production and the number of additional plants that each geographic area could support. Enough unused fine softwood wastes were available at the end of 1970 to produce about 1.5 billion ft^2 of board. Since 1970 the industry has continued to expand, mostly in the South, so that it appears that the easily accessible mill wastes in that area must be about exhausted. In fact, recently announced expansions of 870 million ft^2 in the South are over the estimated supply, which means either that the estimated supply is too low, or that the plants expect to use some other sources of raw material. Both are probably true; at any rate, it appears that the days of cheap mill waste are about over in the South, so that the rate of expansion there will slow down, at least until the rest of the country also runs out of mill waste.

Some indication of the supply situation in the South comes from the announcement that the Evans Products plant in Moncure, N.C., is being converted from softwood mill waste furnish to rough hardwood wastes.

Expected Expansion in the West

New particleboard plants based on fine mill waste will continue to be built in the West until the easily available supplies are exhausted, which will probably occur within the next 2 or 3 years. The unused supplies of fine mill waste in the West are about evenly split among California, the Pacific Northwest, and the Rocky Mountains. The expansions most logically will come in those areas closest to the markets. Southwestern markets (mostly Los Angeles) can best be served by plants in northern California, and the Midwest market, by the Rocky Mountain States. The 1973 *Forest Industries* survey of board manufacturing lists four new western plants. Two are in Montana--at

Columbia Falls and Bonner. One is in California at Oroville and one at Medford, Oregon, which is quite close to the California border. There have been several expansions but no new plants in the rest of Oregon, and none in Washington since 1971.

This pattern of expansion is likely to continue, with several new plants in northern California and one or two more in the Rocky Mountains. Expansion should be somewhat slower in Oregon but may go faster than expected because of the industry concentration already there.

Within the next 2 or 3 years, then, most of the growth in particleboard manufacturing will be in the Western States, and will be located close to the remaining supplies of fine mill wastes. The production of particleboard from other materials, which has already started, should gain momentum so that in several years most of the growth will be based on materials other than softwood mill wastes. To predict the patterns of these further expansions we must examine the other materials available, and the products to be made from them.

Alternate Board Products and Raw Materials

Medium Density Fiberboard.--Of the new products and processes that will affect the particleboard industry in the near future, medium density fiberboard (MDF) looms the largest. Although MDF is a well-defined product, no one in the industry seems to agree as to its classification. Some of the present producers class their output with particleboard, others with hardboard. Its inclusion with particleboard is justified because it is used for the same applications as industrial grades of particleboard.

The essential difference between the usual shavings-type particleboard and MDF lies in the preparation of the material. Particleboard furnish is processed at ambient temperatures and pressures through refiners that reduce the material to particles of the desired size and shape. The particles are then dried, mixed with adhesives and wax, and formed into a mat, usually with finer material on the face and coarser material in the center.

MDF furnish is processed at elevated temperature and pressure, which softens the wood and results in a finer, more fibrous particle. The fibers are then dried and blended as with particleboard, but formation of the mat requires different techniques because of the light, fluffy nature of the material. Most (but not all) MDF is made as a homogenous board, that is, with no difference in the material on the face and the core.

MDF has a smooth face (comparable to good industrial particleboard), good strength, and superior edge machinability, which make it an excellent panel for furniture manufacturing. Perhaps the most important effect of the pressure refining, however, is that almost any wood furnish will make a good board. Ordinary particleboard can also use many materials, but the processing costs and board quality may suffer. Hardwoods are especially difficult to work with and some species of softwoods are also less suitable. Part of the western dominance in particleboard comes from the ease with which high quality industrial board can be made from ponderosa pine and Douglas-fir, which are found only in the Western States. There has thus been a tendency for the western manufacturing plants to produce more of the industrial board and the southern plants to specialize in the less demanding underlayment grades.

Because the MDF process can produce high quality industrial board from hardwoods and southern softwood, much of the growth in MDF production can be expected to occur close to the major markets in the South and Midwest. As usual, mill waste which otherwise constitutes a disposal problem, and is therefore very low cost, will be the preferred material.

Structural Particleboard.--Regional growth of particleboard production will also be influenced by development of structural particleboard. Structural board technology is not as well developed as is that of MDF, and there is still some uncertainty as to how the product will be made and what materials will be used. However, structural board is not a new product. A plant in Saskatchewan, now owned by McMillan Bloedell, began production in 1963 of a structural board called "Aspenite." Aspenite has been quite successful in Canada, where it is used in structural applications and is an approved substitute for plywood under the building codes. The Blandin Paper Company has built a plant in Grand Rapids, Minn., to produce a structural board from aspen, which they have named "Blandex." This plant should be producing sometime in 1974. The market performance of Blandex will be very closely watched to see if it can match the acceptance of Aspenite in Canada. It has two large marketing hurdles to clear: the reluctance of builders to switch from plywood to a new and unknown substitute, and full acceptance by regulatory agencies and building codes. The speed of acceptance will probably depend more on the price and supply of plywood than on the merits of the board itself. A prolonged shortage of plywood would force a more rapid acceptance of structural particleboard. However, if plywood production is able to keep up with or stay ahead of demand, then production of structural board will grow very slowly.

Structural boards differ from normal particleboards in that they have greater moisture resistance and strength. Moisture resistance is easily obtained by substituting a phenolic resin (the same as is used for exterior plywood) for the usual urea resin. The greater strength is obtained by using larger particles, more resin, alining the particles in one direction, or by using any combination of the three. Aspenite is made from large, thin particles (called flakes) in a random arrangement and with about 2.5 percent resin. The strength of the product probably could be increased by using more resin.

The flake size used in Aspenite averages about 1-1/2 inches long, one-half to 3 inches wide, and 0.025 inch thick. Research has indicated that the width of the flake is not important and could be much smaller, but that the long length and thinness of the flake are important to strength. The flakes are made from aspen logs by a flaking process which cuts parallel to the grain, thus producing the long, thin flakes. A chipping action, such as is used for producing pulp chips, cuts across the grain of the wood, which makes chunks or slivers rather than the thin flakes required.

Whatever the final characteristics required for flakes, a good structural board requires flakes cut from a relatively large piece of wood; therefore, fine mill wastes are not suitable furnish. Even a coarse mill waste such as pulp chips apparently will not work well. Structural board could be made from mill slabs and edgings, but with the strong trend toward the chipping of coarse wastes, even in the smaller mills, slabs are not a reliable source for large-scale use. The primary source of material for structural board will be roundwood, and the industry will tend to locate where there are suitable supplies of materials close to the markets.

The Lake States are ideal for the early location of structural board manufacture. There are abundant supplies of aspen; and with the first two structural board plants using aspen, there will be a reluctance on the part of potential manufacturers to experiment with other species unless they must. There are large markets nearby in the North Central States and the northeast coast. The real inducement for a northern location, however, is the freight advantage that a local structural board would have over the plywood that it must displace in the marketplace. Because there is no softwood plywood manufactured in the North, the plywood used in that area must bear freight charges from the South and the West, whereas a locally produced structural board would not.

A structural board produced in the West or South would be competing with plywood produced in the same area, and so would have no freight advantage. In fact, because the particleboard is somewhat heavier than comparable plywood, it would be at a disadvantage that would grow greater as the distance to markets increased.

The rate of growth in the structural board markets is extremely difficult to predict because there is almost no history to use as a guide. Two of the forecasts mentioned earlier, however, include demand for structural boards, and are in very close agreement.

The demand forecasts for 3/4-inch structural particleboard in million ft^2 are:

	1975	*1980*	*1985*
Columbia Engineering (Vajda)	150	900	--
Rocky Mountain Forest and Range Experiment Station (Eagan)	155	820	2,975

At 80 million ft^2 per plant, these forecasts translate into 2 new plants in 1975 and 10 in 1980. With one plant (Blandin) already going, we can expect only one more in the next 2 years, followed by eight in the next 5 years--not a very rapid expansion when compared with the expected growth in particleboard and MDF. It is not until the 1980's that we can expect structural boards to become a major factor in the total wood panel market.

Summary

Expansion of particleboard production within the next few years will tend to follow the established pattern of locating close to available supplies of fine mill wastes, with closeness to markets being a secondary factor. This pattern will continue until the supplies of readily available mill wastes are exhausted.

Mill waste supplies in the South appear to be running out, so that the rapid expansion in that area will slow, with only two to four major new plants expected within the next few years. Expansion will be most rapid in northern California and the Rocky Mountain States, with three or four new plants expected in each area (at an average capacity of 100 million ft^2 per year). Oregon and Washington can expect two or three new mill waste-dependent plants.

By 1976 or 1977 we can expect that most readily available softwood mill waste will be committed to use, so that additional expansion will be based on other sources of raw material. Medium density fiberboard can be made from roundwood or rough mill wastes, either hardwood or softwood, which are widely available. We can thus expect that the next major wave of expansion (after the fine mill wastes are used up) will tend to be close to major markets--the South and Northeast.

The structural board market is expected to grow slowly during the next 5 years, with most of the growth being in the Lake States region. If aspen supplies prove to be insufficient or if there is strong price competition from the pulp industry, the structural board expansion may be forced toward the South or the Rocky Mountains. In any event, there will probably not be much growth in structural board in the West, except possibly for a couple of plants supplying local demands.

ECONOMICS OF PARTICLEBOARD PRODUCTION IN THE NORTHERN ROCKY MOUNTAIN REGION

In assessing the economics of building and operating a particleboard plant in any region, care must be taken that our view not become so general that important details are obscured. Nevertheless, some generalizations must be made if we are to cover a reasonable range of alternatives.

The first section of this analysis will deal with the costs and returns to be expected from a plant operating on mill waste furnish. The second will deal with the estimated costs of producing a structural board from roundwood, with special emphasis on those cost factors that would vary greatly between possible locations.

Cost estimates for both capital and operating expenses have been obtained from three sources: published materials, detailed feasibility studies for prospective plants, and actual costs provided by operating plants. The published costs are from several sources (Gray and others 1970; Raddin 1970; Vajda 1970) and are indicated in figure 6. Detailed estimated costs were provided by Columbia Engineering of Vancouver, B.C. During the summer of 1973, seven operating particleboard plants were visited, and actual cost data were provided by four of them. Because of the confidential nature of the data provided, the plants must remain unnamed, but all are in the Northwestern United States.

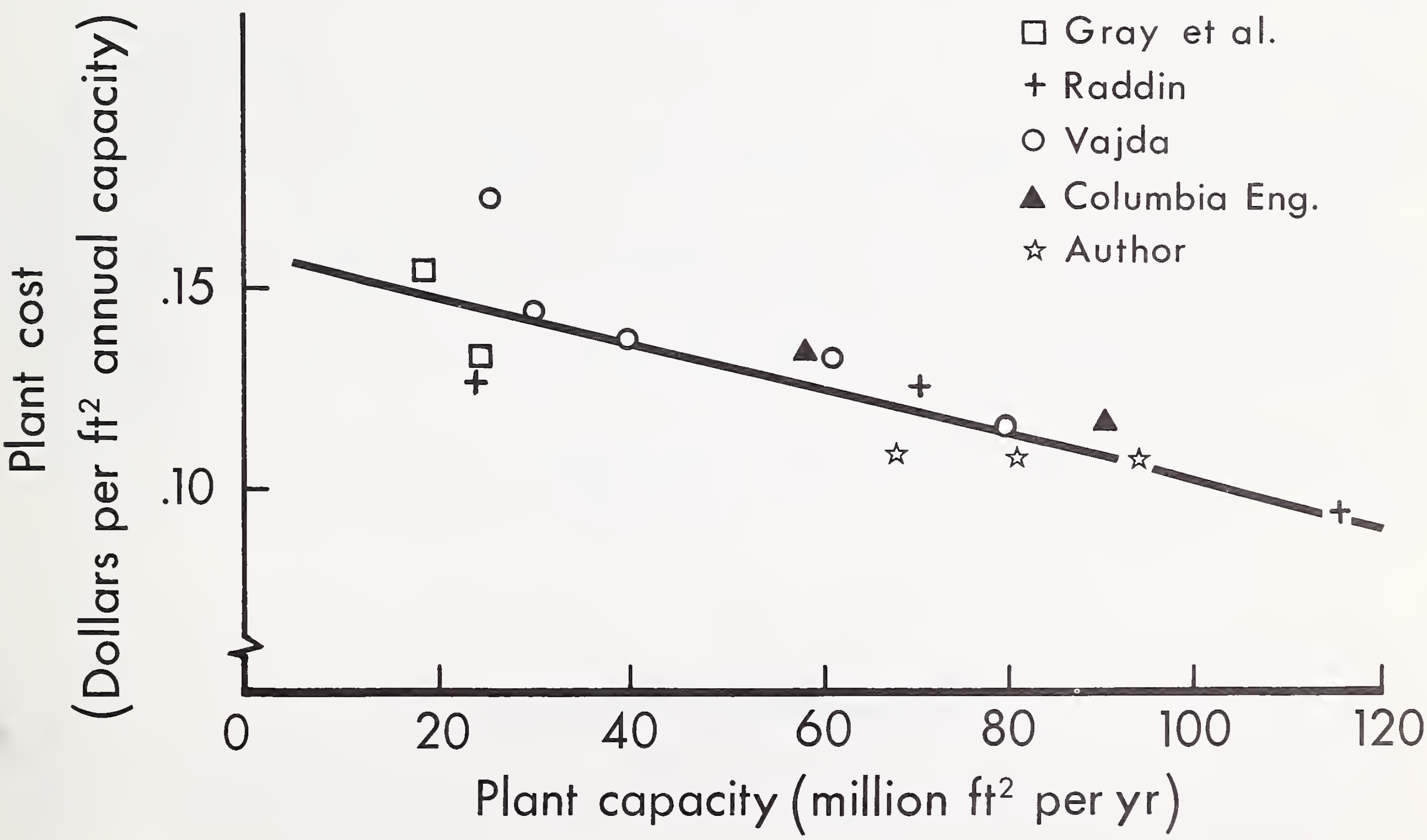


Figure 6.--Particleboard capital costs according to annual plant capacity.

The various estimates obtained were made over a time interval of 10 years, so all were converted to 1973 dollars by use of the implicit price deflator for producers' durable equipment as published in the *Survey of Current Business*.

Capital Cost Estimates

The various capital cost estimates have been converted from total plant costs to cost per square foot of annual capacity, and are shown on figure 6. There is a definite relationship between the capital cost and the size of the plant. Single linear regression was used to fit the line of figure 6, and shows a correlation of -0.88 between plant size and cost. Using this cost relationship, we can construct the following tabulation of expected costs:

Plant size annual capacity (*Million ft^2*)	*Expected cost per square foot of annual capacity* (*1973 dollars*)	*Total capital cost* (*1973 dollars*)	*Standard error of estimate* (*1973 dollars*)
40	.137	5,480,000	±432,000
60	.126	7,560,000	±642,000
80	.114	9,120,000	±864,000
90	.108	9,720,000	±990,000

The standard error shown in the last column is one standard deviation from the estimated regression line, so that we could expect about a two-thirds chance that the total cost of an actual plant of the size shown would be within the standard error. One million dollars looks like a very large possible error, but it cannot be reduced without fixing all of the variables of plant location, exact process, and product specification. For this study, where all of these things must be assumed, the standard error is well within the errors of the other estimates that must be made.

These data include several MDF plants in addition to ordinary particleboard plants. If the MDF plants are excluded, virtually the same results are obtained in the regression analysis. It appears that MDF plants cost about the same as particleboard plants, although some of the costs for individual equipment are quite different.

An economic life of 10 years will be assumed for the entire capital investment. This is a rough average, for some of the equipment will be depreciated much faster or slower. Ten years is the most commonly used estimated life in the various published feasibility studies. It represents an estimate of the expected economic life of the plant rather than the physical life. Major equipment, such as the press or forming line, will surely have a physical life much beyond 10 years, but because of technological advance will probably become uneconomical to operate well before being worn out. The cost of the land cannot be depreciated, but because it represents less than 1 percent of the total capital cost it has not been separated from the other investments.

Operating Cost Estimates

The operating expenses are divided for analysis into the costs of material, which will vary directly with the volume of production; variable operating expenses such as labor, which will be partially dependent on volume; and fixed operating costs, which depend primarily on plant size.

Material Costs

Particleboard contains only three materials: wood particles, resin binder, and a wax emulsion to control moisture absorption. There are no significant indirect materials, such as water or processing chemicals, consumed in the production process.

Actual prices paid for dry mill waste materials are difficult to obtain, as this is generally considered to be confidential information; but most plants expect to pay about $6 per ton, dry weight, for shavings. This price has been stable for some time and does not change as much as does the price of particleboard. Apparently it is the price necessary to induce the mills to collect dry mill wastes separately from other wastes and to provide loading facilities. Of equal importance to the price paid for material is the cost of transporting it to the manufacturing plant. Transportation is nearly always by truck. Even though large volumes are often involved, rail transport is seldom used, primarily because of difficulty in unloading. Most board mills have equipment to dump shavings by tipping the truck or trailer, but have no facilities for unloading railcars.

The cost of transportation will vary by distance traveled and by the amount of time taken loading and unloading. For short hauls, the usual rig is a tractor-trailer with a capacity of 17 units, or 20.4 tons dry weight. Longer hauls generally use a truck-trailer combination with a capacity of 23 units, or 27.6 tons. Approximate costs, which will vary somewhat with the type of road and the speed of the unloading equipment, are:

	Truck-trailer	*Tractor-trailer*
Turnaround time, each end	1/2 hour	1/4 hour
Turnaround cost per ton (1973 dollars)	$0.72	$0.50
Transport cost (1973 dollars)	$0.036 per ton per mile	$0.05 per ton per mile

The break-even point between the two methods is about 15 miles. The total transportation cost, of course, depends on the length of haul, which cannot be accurately determined without actually selecting a plant site and determining the distances to suppliers. Board plants will be located close to concentrations of material, but several cases were found in which significant amounts of shavings were hauled over 200 miles. If we assume that 75 percent of the material will be at an average distance of 20 miles, and will be moved by tractor-trailer and 25 percent will be at an average distance of 100 miles, to be moved by truck-trailer, the following costs (in 1973 dollars) result:

Short hauls: ($0.50) + (20)(0.05) = $0.50 + $1.00 = $1.50/ton

Long hauls: ($0.72) + (100)(0.036) = 0.72 + $3.60 = $4.32/ton

Average cost: (0.75)($1.50) + 0.25($4.32) = $2.20/ton

The costs of resin and wax emulsion are extremely volatile and are rising sharply, as are the costs of all petroleum-based chemicals. During the early summer of 1973, the average prices were $0.075 per pound for urea-formaldehyde resin, and $0.05 per pound for wax emulsion, based on the weight of solids. (Both are produced and used as a liquid.) Average usage is 6 percent resin and 1 percent wax.

To convert these costs to dollars per 1,000 ft^2 of particleboard, a conversion of 1.5 tons of wood per 1,000 ft^2 is used. This allows for some shrinkage from trim and sanding, as the finished 45-pound density board weighs 2,812 pounds per 1,000 ft^2. The total direct material costs per 1,000 ft^2, 3/4-inch basis, (1973 dollars), are:

Wood cost	$ 9.00
Transportation	3.30
Resin	13.20
Wax	1.50
Total	$27.00

Labor Costs

Estimated manning per three-shift day and the average costs (at 1973 rates) are shown in table 2 for 60 and 90 million ft^2 plants. The actual number on the payroll will be one-third more than shown, to allow for manning during weekends and vacations. In assigning average wage rates, the jobs have been classed as either skilled labor or supervisory/maintenance. The rates shown are representative rates for comparable jobs in wood processing in the western Montana area. Averages used are $3.75 plus $1.15 for fringe benefits and vacation for skilled labor and $4.25 plus $1.25 for foremen and maintenance men.

As with the capital costs, there are obvious economies of scale in the cost of labor for larger plants. Particleboard manufacturing is highly mechanized, with many segments of the operation approaching full automation. The function of most of the process operators is primarily to oversee the operation of each segment and make occasional corrections. It takes no more men to watch a large machine than a small one. Only in the material handling and shipping functions do we find a direct relationship between volume and labor.

Energy Costs

Particleboard production requires large amounts of electrical power, primarily in the refining and the pressing operations. In both of these operations power usage is directly related to the volume of production. Power usage, estimated from the three operating plants surveyed and one detailed feasibility study, averages 250 kilowatt hour (kwh) per 1,000 ft^2 of 3/4-inch particleboard. Prices paid for power show considerable variation, depending on the location and the utility providing the service. In Montana, the estimated charge is $0.011 per kwh including demand charges (estimated from Public Service Commission of Montana, Sheet No. Gs-72, October 1972). The total power cost is estimated as $2.75 per 1,000 ft^2 of particleboard.

In all plants surveyed, natural gas, or propane when natural gas is not available, is used for drying the wood particles after they have passed through the refining process. Although gas is used in nearly all dryers, the survey revealed widespread interest in developing alternate heat sources such as sander dust or hog fuel. Many plants are likely to be cut off from natural gas supplies during each winter. Propane is easily substituted, but is more expensive and may be even more difficult to obtain than natural gas.

The most attractive substitute for natural gas appears to be a heat exchanger in the dryer to utilize the heat from process steam. Such a system would substantially add to the cost of the dryer, and could still require some gas to finish the drying and to allow for the necessary fast control, but would markedly reduce the demand for gas.

Table 2.--*Estimates of labor costs in particleboard plants in the Northern Rocky Mountain region, 1973*

Operation	Labor rate per hour[1]	Number of workers per day — Plant size: 60 million ft^2	90 million ft^2
Yard	$4.90	5	5
Milling & drying	4.90	3	3
Blending	4.90	3	3
Forming	4.90	3	3
Pressing	4.90	3	3.
Finishing	4.90	11	12
Material handling	4.90	5	8
Cleanup & helpers	4.90	18	22
Boiler	4.90	3	3
Laboratory	4.90	3	3
Shift millwright	5.50	3	3
Shift electrician	5.50	3	3
Knife grinder	4.90	2	3
Shipping	4.90	8	12
Foreman	5.50	3	3
Maintenance foreman	5.50	1	1
Maintenance millwright	5.50	1	2
Maintenance electrician	5.50	1	1
Maintenance helper	4.90	1	2
Total workers per day		80	95
Labor cost per day		$3,193	$3,786
Labor cost per year (350 days)		$1,117,550	$1,325,100
Cost per 1,000 ft^2		$18.50	$14.72

Source: Manning tables provided by Columbia Engineering International, Vancouver, B.C. Average wages calculated from contracts provided by the Missoula County Trades & Labor Council, Missoula, Montana.

[1]Includes wages plus fringe benefits.

Current usage of natural gas is about 1,500 ft^3 per 1,000 ft^2 of particleboard production. The usage rate varies, depending on the weather and the moisture of the wood particles. Shavings, which make up the bulk of the furnish, are normally quite dry, and passing chips through the dryer serves mainly to maintain a uniform moisture content rather than actually to dry them. Wetter-than-usual wood or a humid day can easily double or triple the usual gas demand.

Gas prices also vary, depending on location. Using western Montana gas prices of $0.48 per 1,000 ft^3 as a norm, the cost for drying will be $0.72 per 1,000 ft^2 of particleboard production at 1973 prices. With uncertainties about supply and the possibility of rapid price increases, this figure could easily double within the next year.

Particleboard production requires steam for heating the press, for building heat and, in the case of MDF plants, for heating and softening the wood particles. Older plants generate steam from natural gas or other fossil fuels, but nearly all newer installations have boilers fired with sanderdust, a very fine mixture of wood and resin collected in filter systems. Sanderdust presented a serious disposal problem until the introduction of boilers designed to burn it. The dust makes a very clean and easily handled fuel. The production of sanderdust and the demand for steam seem to be nicely balanced, with most plants burning all of their dust and using most of the steam produced.

The cost of installing the boiler has been included as a part of the total capital cost, and once it is installed the operating costs will be small, so that no extra cost for steam has been included in the cost analysis.

Total Costs

The estimated annual administrative and overhead expenses are $4.50 per 1,000 ft^2 for a 60 million ft^2 particleboard plant and $3.53 per 1,000 ft^2 for a 90 million ft^2 plant (table 3). When these costs are added to materials, fuel, labor, and other costs, the total expected production costs for a particleboard plant in the Northern Rockies are $70.98 per 1,000 ft^2 for a 60 million ft^2 plant and $64.06 per 1,000 ft^2 for a 90 million ft^2 plant (table 4).

Table 3.--*Estimated annual administrative and overhead expenses of a particleboard plant in the Northern Rocky Mountain region, 1973*

	Plant capacity	
	60 million ft^2	90 million ft^2
Salaries, including payroll costs:		
Plant manager	$ 25,000	$ 28,000
Plant superintendent	18,000	19,000
Technical director	15,000	15,000
Bookkeeper	12,000	12,000
Clerk/Stenographer	18,000 (2)	27,000 (3)
Shipping clerk	12,000	12,000
	$100,000	$113,000
Insurance	40,000	50,000
Property taxes	70,000	90,000
Office expenses	60,000	65,000
	$ 27,000	$318,000
Overhead per 1,000 ft^2	$4.50	$3.53

Table 4.--*Summary of expected production costs of a particleboard plant in the Northern Rocky Mountain region, 1973 (per 1,000 ft², 3/4-inch basis)*

	Plant capacity	
	60 million ft²	90 million ft²
Wood	$12.30	$12.30
Resin	13.20	13.20
Wax	1.50	1.50
Power	2.75	2.75
Fuel (gas)	.72	.72
Labor	18.63	14.72
Maintenance and supplies	2.00	2.00
Overhead expense	4.50	3.53
Operating contingency (5%)	2.78	2.54
Subtotal	$58.38	$53.26
Reserve for depreciation (10-year straight line)	12.60	10.80
Total	$70.98	$64.06

PRODUCT MIX, PRICES, AND NET RETURN TO MILL

Few established particleboard plants produce only one type of board, and all of them produce a variety of thicknesses. Most new plants have been aimed at the industrial board markets, where profits are generally higher than for nonindustrial board types. Unfortunately, there are no reliable estimates of prices for industrial grade boards, primarily because the product class includes many special varieties and may include much secondary processing.

Whatever the final market goal, there seems to be a tendency for new plants to produce underlayment particleboard, and to move into the industrial market after they are well established. Underlayment is less exacting to manufacture than industrial board and has a ready market that requires less sales effort. The following analysis will consider only underlayment grades, because any new plant will likely be forced to exist for the first several years without any substantial industrial grade production. The capital costs of a new plant that were developed earlier (fig. 6) were based on the presumption that the plant would have equipment suitable for industrial board. It is assumed here that the industrial grade capabilities will not be utilized in the early years, so that the plant must prove profitable on underlayment alone. A plant built to make underlayment only would cost significantly less.

All summary statistics for the particleboard industry are reported on the basis of 1,000 ft^2 of board 3/4-inch thick. However, very little underlayment grade is actually three-fourths inch; most is five-eighths inch or less. Underlayment production in 1972, as reported by the U.S. Department of Commerce, included the following sizes:

Thickness *(Inch)*	*Quantity* *(Million ft^2)*	*Production percentage* *(Percent)*
5/8	643	68
1/2	130	14
other (mostly 3/8)	167	18
Total	940	100

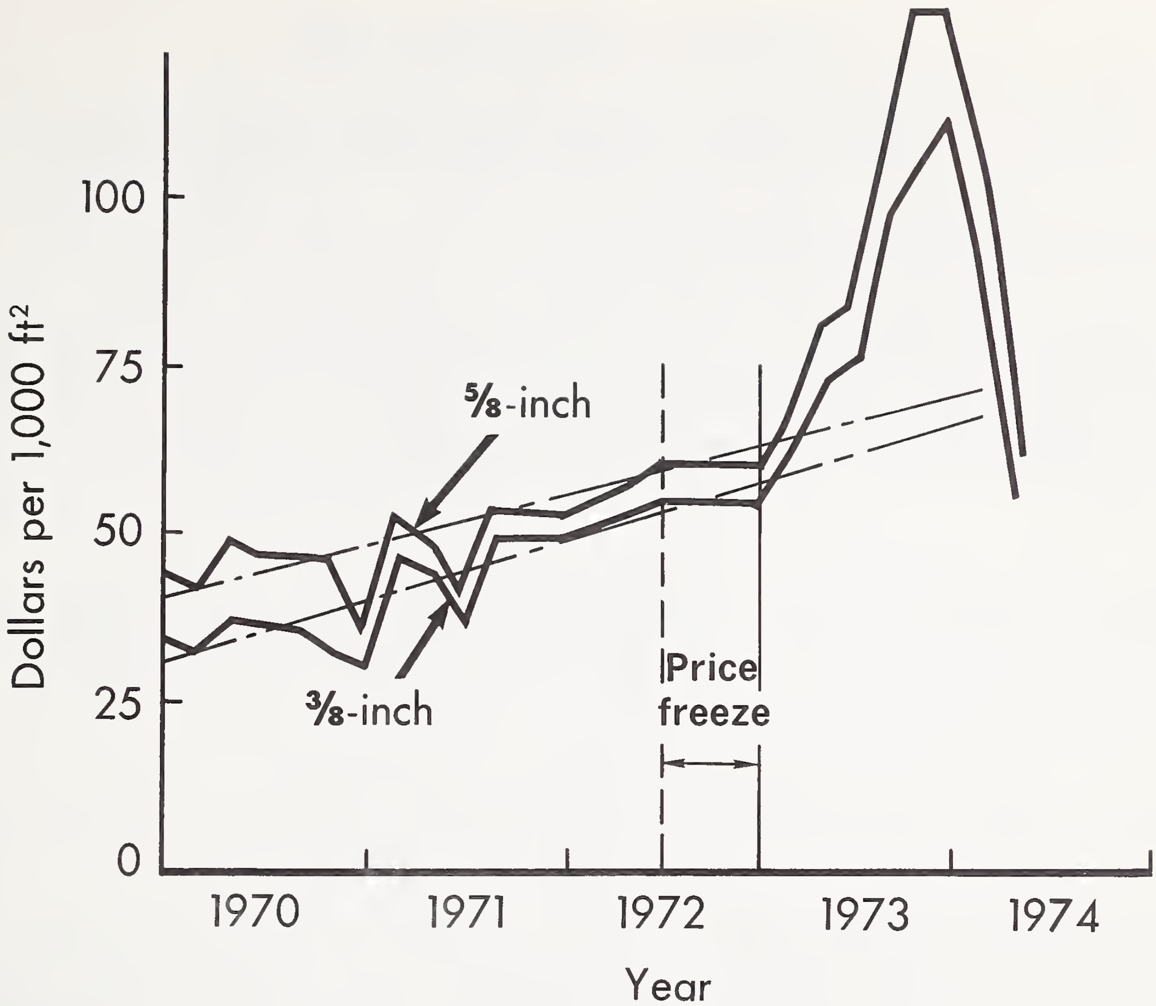


Figure 7.--Particleboard prices; western underlayment, f.o.b. west coast. Source: Crows Plywood Newsletter 1970-1974.

It is assumed that the typical plant will produce in this ratio, so that weighted averages of the prices can be converted to an expected price on a 3/4-inch basis.

Particleboard Prices

Prices for western particleboard are published every Friday, based on average prices f.o.b. West Coast. The data are both complete and accurate. We can easily see what prices have been, but predicting future prices is another matter. Like the prices of other wood products, particleboard prices have been subject to severe fluctuations, so that any long-term projections will be influenced very heavily by what one chooses as the base period from which to forecast.

Bimonthly prices for 3/8- and 5/8-inch particleboard since January 1970 are shown on figure 7. Prices for 1/2-inch particleboard lie between the two but have been omitted for clarity. The time series was started in 1970 because prices have been quite stable from 1970 until mid-1973. A very different picture would emerge if 1969 were included. During 1969 the price of 5/8-inch board rose to a high of $120 before plunging to the $45 shown at the beginning of 1970.

The capital and operating costs estimated in the previous sections were all converted to 1973 dollars, so that the price estimates for board sales should also be for 1973. Because we have prices for all of 1973 it is tempting to simply calculate the average for the year. A simple average may be very misleading, however, because of the effects of the price freeze during the latter half of 1972.

Particleboard prices were frozen in July of 1972 (at $58 for 5/8-inch board) following a 2-year period of steadily rising prices. The freeze extended until the end of January 1973. During the period of the freeze, demand was heavy and production fell well behind demand. When the freeze was lifted, producers had large backlogs of unfilled orders and demand was still strong; as a result, prices shot upward. Prices increased steadily to $130 at the end of November 1973, stabilized for a short while, then dropped sharply starting in February 1974.

Particleboard prices since the start of the price freeze in mid-1972 are extraordinary, and should not be used to predict the economic feasibility of particleboard manufacturing in the future. We need an estimate of prices had there been no price freeze. The two dashed lines on figure 7 are linear extensions of the prices from January 1970 through June 1972. Extending these trends into 1973, we can estimate the following prices:

Board thickness	*Projected price*	*Equivalent price, 3/4-inch*	*Percentage of total sales*
(Inch)	*(Dollars)*	*(Dollars)*	*(Percent)*
5/8	67	80.4	68
1/2	65	97.5	14
3/8	62	124.0	18

(Weighted average price, 3/4-inch basis: $90.64)

These price estimates exclude both the short period of high prices in 1969, and the abnormal period of the price freeze and subsequent price "bubble." This selection of a time period of low, stable prices as the forecast base means that the price estimates are conservative. There may be short-term fluctuations of prices below the estimate, but we can reasonably take the prices shown above as a minimum expected price.

Basing the expected profitability of a plant on minimum prices will yield pessimistic results, so that we should also establish an upper range for the expected sales price. We cannot, however, use the same technique as used for establishing a low range; that is, we cannot select a period of stable high price as a forecast base, because there have been no such periods. There have been high price periods, but they were too unstable to serve as a forecasting base. Attempts were made to find correlations between the price of particleboard and indicators such as gross national product, housing starts, and plywood prices. The results were disappointing. No useful indicator with significant predictive ability was found. The price of plywood has good correlation with the price of particleboard, but since the two tend to be coincident, plywood price is not useful as an indicator of particleboard price.

A high price range 25 percent above the minimum will be used to examine the effect of higher sales prices on the profitability of particleboard manufacture. In view of the very large fluctuation in prices over the past 5 years, a price 25 percent above the minimum is well within the range of possibility. The correct figure is probably somewhere between the two.

The prices shown in figure 7 have already been adjusted for trade and price discounts (5 and 3 percent), but do not include freight charges. Any differences between actual freight cost and the cost from the west coast would show as an effective difference in total price. Freight charges of course depend on the origin and destination, but plants in the Northwestern Rocky Mountain region can expect to enjoy an advantage of about $2 per 1,000 ft^2 over west coast shipments to the Midwest or east coast. This difference will appear as a higher effective sales price at the mill.

Rate of Return on Investment

The expected costs and incomes developed in the previous section have been summarized in tables 5 and 6, which also show the expected first-year rate of return on the original investment.

Table 5 is based on the low price estimate, which averages $90.60 per 1,000 ft^2 on a 3/4-inch basis. At this price, the estimated first-year return of 9 and 12 percent for the two plant sizes would be acceptable for an operating plant but would probably not be high enough to induce new plant construction. It should be noted that the first-year return on investment is in itself a very conservative method of viewing the value of an investment. The actual return will rise each year as the plant and equipment are depreciated. The internal rate of return over the 10-year life is 16 percent instead of 9 percent for the 60 million-ft^2 plant.

Table 6 presents the return at a sales price 25 percent higher than table 5, or $113.25 per 1,000 ft^2, 3/4-inch basis. At this price the first-year return on investment nearly doubles for both sizes of plant, to 18.4 and 21.6 percent. The returns shown in these two tables represent the pessimistic and optimistic extremes that can be expected. The true return on investment is probably somewhere between the two.

First-year returns of about 15 to 20 percent should be sufficient to attract capital to the industry, so that we can expect to see continued growth of particleboard production in the Northern Rocky Mountain region.

Table 5.--*Low price estimate: expected return on investment for millwaste particleboard*

Return factors	Plant size: 60 million ft^2	Plant size: 90 million ft^2
Sales price per 1,000 ft^2		
3/4-inch basis	$ 90.60	$ 90.60
Plus freight advantage	2.00	2.00
Net price to mill	$ 92.60	$ 92.60
Cost of production[1]	70.98	64.06
Net income per 1,000 ft^2	$ 21.62	$ 28.54
Taxable income per year	$1,297,200.00	$2,568,600.00
Income tax (6-1/2% State, 48% Federal)	706,974.00	1,399,887.00
Net income per year	$ 590,226.00	$1,168,713.00
Original investment	$6,560,000.00	$9,720,000.00
First-year return on investment (%)	9.0	12.0

[1]From table 4.

Table 6.--*High price estimate: expected return on investment for mill waste particleboard*

Return factors	Plant size: 60 million ft^2	Plant size: 90 million ft^2
Sales price per 1,000 ft^2		
3/4-inch basis	$ 113.25	$ 113.25
Plus freight advantage	2.00	2.00
Net price to mill	$ 115.25	$ 115.25
Cost of production[1]	70.98	64.06
Net income per 1,000 ft^2	$ 44.27	$ 51.19
Taxable income per year	$2,656,200.00	$4,607,100.00
Income tax (6-1/2% State, 48% Federal)	1,447,630.00	2,510,870.00
Net income per year	$1,208,570.00	$2,096,230.00
Original investment	$6,560,000.00	$9,720,000.00
First-year return on investment (%)	18.4	21.6

[1]From table 4.

ROUNDWOOD AND FOREST RESIDUE FURNISH

The preceding cost analysis was based on the assumption that the bulk of the raw material for any new particleboard plant would be fine mill wastes. As long as there are adequate supplies of these mill wastes in the Nation, we can expect that there will be no major usage of other materials (with the exception of some structural board made from roundwood).

As mill wastes become more fully utilized, there will be a trend toward the use of roundwood and wastewood now left in the woods. It must again be emphasized, however, that uncommitted mill waste supplies should be available for another 3 or 4 years, and that the question of plant location cannot be viewed from a local point of view. As supplies of mill wastes are exhausted in a sector such as the South or the Northwest, we cannot expect that additional particleboard manufacture in those areas will be forced to roundwood supplies. Instead, production expansion in those areas will cease and will be shifted to areas that still have cheap materials. Only after the nationwide supplies of mill wastes are largely committed will there be a significant shift to other furnish material.

The first large-scale use of forest residues should come in those areas that are close to large markets and have large supplies of residue materials. Because most areas (except the Plains States) have plentiful forest residues, closeness to market should be the prime factor in determining plant location. Therefore, basing our judgment on the location of residues and markets, we might expect the first move of expansion to be in the Northeast followed by the South and northern California, then the Rocky Mountains, and finally the Pacific Northwest. Besides materials and markets, however, there are a number of other factors to be considered which may alter the patterns.

The Northeast

There are large quantities of wood residue and small roundwood available in the Northeast, mostly in mixed hardwood species (USDA Forest Service 1973). With major markets nearby, the area would seem a natural for board manufacture. There are several factors which will slow development in this area, however. The mixed hardwood species available in the Northeast will make good board, but are much more difficult to work with than softwood. Most expansion will probably be in MDF plants, since the MDF process accepts hardwood more readily than a standard particleboard process.

Although there are large quantities of hardwood forest residues, the material is much more scattered than the residues in the softwood regions. Ownership is mostly private and often scattered among small holdings. Most harvesting and processing operations are small, so that collection of residue will be difficult and costly. Particleboard manufacture requires a reliable source of large quantities of material. Plants in the Northeast could not rely on residues for a steady supply, and would be forced to use specially cut roundwood, which would substantially increase the cost of material. It is unlikely that the transportation savings of about \$50 per 1,000 ft^2 of particleboard over west coast plants would be enough to offset the increased wood costs. Eastern plants would be at an additional disadvantage with higher construction costs, higher wages, and much higher energy costs.

The South

The South also has large quantities of unused residues, and although the supply there also is somewhat scattered among small operations, there appears to be a strong trend toward larger concentrations. Both softwoods (pine) and hardwoods are available. With its close proximity to major markets and large dependable supplies of residues, the South will likely be one of the first areas to go into large-scale utilization of forest residues for particleboard.

Northern California

Northern California has a large nearby market in the Southwest, and vast quantities of forest residues. In addition, the residues produced in logging are concentrated because of the dense timber stands and large-scale logging operations. Everything appears ideal for utilization of forest residues except that there are still unused mill wastes available for particleboard production. The forest residues will not be used until all mill wastes are committed, which may take 3 or 4 years. Once the mill wastes are gone, however, the use of forest residues in California should proceed rapidly.

Rocky Mountains

In addition to logging residues, the Northern Rocky Mountain areas have large tracts of dead timber that would be suitable for particleboard. Collection of forest residue materials, however, will be more difficult and expensive than in the South or along the Pacific Coast. Rugged terrain, severe winters, and lower density stands that require collection over greater areas will make residue use less feasible in the Rockies than it will be in the South or Far West. These disadvantages will be somewhat offset by slightly lower operating costs for labor and energy, and by some advantage over the West Coast on transportation cost.

The Pacific Northwest

Oregon and Washington appear to be unlikely locations for forest residue uses because of the greater distance to markets. Three factors favor this region, however: the high density of forest residues, the species available, and the existing concentrations of particleboard manufacturing plants.

The dense stands of timber along the Pacific Coast produce equally dense concentrations of forest residues, especially logging residues. Heavy concentrations, along with the mild climate that allows year-round work, will result in easier and cheaper collection of forest residues.

The species mix of mostly Douglas-fir and ponderosa pine also favor expansion of west coast production. Although nearly any wood fiber will make a decent board, it has been found that these species are two of the easiest to work with.

Finally, the existing concentrations of particleboard manufacturing in Oregon should not be overlooked. There are subtle advantages in locating close to others in the same industry. Interchange of ideas, help with mutual problems, and the growth of adequate services all come from industry concentrations. So long as nearby plants are not forced to compete for limited raw materials, the concentration is desirable; and for plants designed to operate on forest residues, there is enough for all for many years to come.

Effects of Structural Board

As mentioned earlier, structural particleboard is not expected to be a major factor in the industry before about 1980, at which time there may be as many as 10 plants in the United States. The early growth will almost surely be based on aspen roundwood, and will be located in the North Central States, because that is the site of initial development. Later expansion, however, will probably be based on utilization of forest residues. Mill wastes are not really suitable for structural board and will, at any rate, be mostly committed to other uses. Forest residues appear to be a natural furnish for structural board. As with other panel products, the South has a definite advantage, with ample wood supplies and short hauls to markets. The first big growth in structural board manufacturing in the late 1970's and early 1980's probably will occur there.

The Northwest and Rocky Mountain States appear to be on the bottom rung as far as structural board is concerned. Except for the two or three plants supplying the California and local markets, the freight disadvantage of \$50 to \$60 per 1,000 ft^2 will be a strong deterrent to rapid growth. The Northwest may have one advantage: the superior physical characteristic of the species available. Douglas-fir in particular is a very strong, easily worked wood. It may be that a superior board could be manufactured in the Northwest at some savings in operating cost over the South or Midwest. The higher strength of the western softwood may also allow a significant decrease in the amount of resin required. At present prices, the cost of the phenolic resin amounts to about 10 to 15 percent of the manufacturing cost of the board. With resin prices expected to rise even more rapidly than those of other commodities, a saving in resin could be quite significant by 1980.

MANUFACTURING COST: MILL WASTE VS. FOREST RESIDUE

Disposing of forest residues, especially those created by logging, is a growing problem, and the manufacture of particleboard would seem to be a good solution. As indicated earlier, however, roundwood is less desirable than mill waste for standard particleboard or medium density fiberboard because of lower costs and ease of handling for mill waste. On the other hand, some of the added costs of using forest residues may be offset by the value of cleaning up the forest floor. In this section we will attempt to estimate the cost differences between using forest residues and dry mill wastes.

Collection of Residues

Forest residues may be loaded on trucks and hauled intact to the processing plants, or may be reduced to chips in the field. The choice of technique will depend on the nature of the residues and the type of terrain. Large residues consisting primarily of cull logs in rugged terrain with poor roads can best be handled whole by the same equipment used for sawlogs. Small or irregularly shaped residues located in easily accessible areas can more easily be chipped on site and hauled to the processing plants in chip trucks.

Whatever method of collection is used, one of the most significant differences between forest residues and dry mill wastes--bark--must be dealt with. The effects of bark in particleboard are difficult to explain. Since most particleboard is made from mill wastes that contain no bark, there is generally no bark in particleboard. It is possible, however, to use up to about 10 percent bark in the board without serious change in the physical characteristics. About 2 years ago a large west coast producer did just that, even advertising in trade journals that the addition of the bark did not change the board, allowed lower prices, and helped solve the bark disposal problem, all of which was quite true. The customers would not accept the board. Although the bark did not affect the physical properties of the board, it was very visible even in small quantities, as it has a much darker color than the wood particles. Since most particleboard is covered by floor coverings, overlays, or paint, it is difficult to explain this reaction, but it was firm. The producer had trouble getting rid of the "bark board" and rebuilding his reputation for producing a quality board. This episode is well known in the board industry, and other producers will have nothing to do with utilizing bark.

Any forest residue collection system must provide for bark removal, which may eliminate some types of residues as a possible source of particleboard furnish. Although barking and chipping equipment is available (Host and Lowery 1970), good cost estimates were not found because the great variability of residues makes any generalized estimate meaningless. No attempt will be made to estimate the cost of collecting, debarking and chipping, and transporting residues to the plant site.

Once the chipped residues are delivered, there are still differences in the cost of processing between residues and dry mill waste.

Operating Cost Differences

The processing of chipped forest residues will differ from the processing of dry mill wastes up to the point that the particles are refined to the desired size and shape and are dried; from then on there will be no differences. Cost differences will exist, then, in raw material storage, refining, and drying.

It is expected that a plant operating on chipped forest residues will maintain a much larger inventory of raw material than it would if it were using mill waste, especially if the residues are located in mountainous country. Collection of forest residues cannot be relied upon as a steady source of material. Many forests will be inaccessible in the winter, and dry summers may cause closure because of fire danger. Supplies of mill wastes do not fluctuate because sawmills maintain an inventory of logs, but a particleboard plant operating on forest residues would need its own large inventory.

Inventories of dry mill waste vary greatly, from enough material to last 5 days (in Oregon) to about 2 months (in Montana). The very small inventories of raw material found in all Oregon plants are primarily due to an Oregon law requiring inside storage for all dry mill wastes to avoid air pollution from particles and dust. Even a 5-day supply requires a very large building or silo. The small inventories are tolerable because of the closeness of the sources and the generally mild weather, which rarely stops the chip trucks. In Montana outdoor storage is allowed, and the possibility of severe storms which will stop the supply of mill waste dictates a buildup of about a 2-month supply of materials.

Chipped residues will be stored outside, and the average plant will have about a 5-month supply. Capital costs will be increased because of the extra storage space required. An extra 4 acres, at $6,000 per acre (with improvements) is estimated. Of more importance is the extra investment in inventory. At a value of $8 per ton, a 5-month supply for a plant of 90 million ft^2 annual capacity represents an investment of about $600,000. The extra land and inventories do not depreciate, but will add substantially to the capital investment and working capital requirements. At an interest charge of 10 percent, these added investments amount to $62,000 per year, or an additional cost of $0.69 per 1,000 ft^2.

The milling and drying of chipped residues will require more equipment and will cost more than mill waste. The chips are both larger and wetter than mill waste, and so will pass more slowly through the refiners and dryers. It is estimated that a 90 million ft^2 plant will require two extra refiners at $50,000 each, and one extra dryer, at $60,000 (1973 prices). With a 10-year depreciation and at 10 percent interest, the added capital cost is about $26,000 per year, or $0.29 per 1,000 ft^2.

Additional energy for refining and drying is expected to add 50 percent to the electrical power requirements and to double the gas requirement. The added energy costs per 1,000 ft^2 are $2.10 (at 1973 prices).

The total added cost for forest residue furnish, then, is $3.08 per 1,000 ft^2 of particleboard: $0.69 for increased investment in storage facilities and inventory; $0.29 for additional equipment; and $2.10 for energy. At 1-1/2 tons of wood per 1,000 ft^2, the added cost is about $2 per ton. To be competitive, then, forest residues must be debarked, chipped, and delivered to the plant site for about $2 per ton less than dry mill waste, or for about $6 per ton. The transportation cost alone is likely to be close to the $6 per ton value of the chips, so that collecting, debarking, and chipping costs would need to be almost zero for forest residues to compete successfully with mill waste as a raw material for particleboard.

PARTICLEBOARD LOCATIONS IN THE NORTHERN ROCKIES

The Northern Rocky Mountain region currently has two operating particleboard plants: Tenex at Sandpoint, Idaho, and Evans Products at Missoula, Mont. Plum Creek Lumber has built and is just starting operation of a new MDF plant in Columbia Falls, Mont., and Champion-International has announced plans to build a plant near Missoula. The industry is moving rapidly into this region and we can expect further rapid growth.

The new plants will be located close to large steady sources of mill waste, as long as it lasts. Except for rail service at the plant site, which usually is available wherever there are sawmills, there are no other special requirements for particleboard plants.

Estimates of concentrations of mill wastes may be obtained by noting the location of sawmills and plywood plants. Table 7 summarizes sawmill and plywood output in 1972, as reported by the *Forest Industries* annual survey (Lambert 1973). This survey is known to be incomplete, but does include most of the larger mills and is sufficient for locating concentrations of mill waste. The region has been divided into 10 areas, primarily by major watershed. Roads tend to follow the major valleys, so that movement of mill wastes would be much easier along rivers than between river systems.

Table 7.--*Northern Rocky Mountain mill waste estimate, 1972*

Type of mill waste		Location of mill or plywood plant								
		Kootenai	Flathead	Lower Clark Fork	Upper Clark Fork	East side Montana	Coeur d'Alene	Clearwater	Lower Snake	Upper Snake
Sawmill production (million bd ft)	(1)	312	340	162	251	89	560	510	449	145
Production by mills over 20 million bd ft yr	(2)	305	307	162	245	0	463	435	439	110
Chips (1,000 tons)	(3)	157	158	84	126	0	239	224	227	57
Sawdust (1,000 tons)	(4)	80	81	43	65	0	122	115	156	29
Shavings (1,000 tons)	(5)	58	59	31	47	0	89	84	84	21
Plywood production (million ft^2)	(6)	70	215		210		145	300		
Green chips (1,000 tons)	(7)	24	74		73		50	104		
Dry trim (1,000 tons)	(8)	6	19		18		13	26		
Total green chips (1,000 tons)	(9)	181	232	84	199	0	289	238	227	57
Total fine wastes (1,000 tons)	(10)	144	159	74	130		224	225	240	50
Already committed to particleboard (1,000 tons)	(11)		120		135		30			
Unused fine wastes (1,000 tons)	(12)	144	39	74			194	225	240	50

Production of all reporting mills is shown in the first line, and the total production from mills which produced 20 million bd. ft. or more during 1972 is on the second. On the assumption that mill waste will be available only from the larger mills, the lower figure has been used to estimate the amounts available. The amount of residues generated by lumber and plywood production has been estimated by use of the following conversion factors, which were developed from surveys of Oregon mills (Manock and others 1970).

Residues from lumber production in dry tons of waste per 1,000 bd. ft.:

	Conversion Factor
Coarse residues	
Suitable for pulp chips	0.516
Sawdust	.264
Planer shavings	.192

Residues from plywood production in dry tons of waste per 1,000 ft^2 (3/8-inch basis):

	Conversion Factor
Coarse residues	
Suitable for pulp chips	.346
Dry trim	.088

Lines 9 and 10 in table 7 shows the total pulp chips and total dry mill waste generated in each area. Particleboard production would be based primarily on the fine wastes, but could use pulp chips. Line 11 gives the approximate amount of mill waste already committed to the particleboard plants at Columbia Falls and Missoula, Mont., and at Sandpoint, Idaho. The proposed Champion-International plant at Bonner is not shown, as its size is unknown. Its inclusion would appear to overcommit the supplies in the upper Clark Fork area, but it should be noted that the Bonner sawmill and plywood plant were not reported in the 1972 survey, as they were not producing then.

The typical new particleboard plant can be expected to be designed for an annual capacity of about 60 to 100 million ft^2 which would require 90,000 to 150,000 tons of wood residue per year. It then appears that there will be sufficient fine mill waste in the Northern Rockies for four or five plants.

In Montana the only uncommitted concentration of mill waste is in the Kootenai Valley around Libby. Unused residues in the Flathead (Kalispell) and the lower Clark Fork (Thompson Falls) areas combined would probably be enough to support a plant, but the area involves long hauls and so would be less desirable than the locations in Idaho.

Three areas in Idaho show definite concentrations. The areas around Coeur d'Alene, the Clearwater drainage (Lewiston or Orofino), and the lower Snake region around McCall or Grangeville all have dry mill wastes of 200,000 tons per year or more.

With these rather large supplies of mill waste available in the Northern Rockies and the shrinking supplies elsewhere in the Nation, we can expect that the particleboard industry will be building here within the near future, and will have most of the mill waste committed to production within the next 5 years.

No attempt will be made to identify specific locations for new plants. Effective transportation and utilities are the most essential requirements for a plant. Good highways for raw material delivery and rail service for finished products are essential, but are widely available throughout the region. Compared to the costs of equipment and operation, any differences in site cost, local taxes, or wage rates among possible sites are negligible.

ECONOMIC AND ENVIRONMENTAL EFFECTS OF PARTICLEBOARD PRODUCTION

From both the economic and environmental viewpoints, a particleboard plant should be a welcome addition to the industrial base of any community.

The most obvious economic effect is the net addition of permanent jobs in the community. A 90 million ft^2 capacity plant will employ about 125 persons for full three-shift operations. Because of the high degree of mechanization of particleboard manufacture, most of these jobs will require skilled labor, and will tend to have higher average wages than other local industries such as lumber mills. Of particular importance is the expected stability of these jobs. The wood products industry tends to be quite cyclical, with occasional large fluctuations in employment. The high capital investment in a particleboard plant makes it uneconomical to follow these fluctuations, so that once a plant is established it will be operated at close to capacity if at all possible. The result will be a steady employment pattern all year long for the life of the plant, which would be for a minimum of 10 years, and probably much longer.

The environmental effects of particleboard manufacture are, on the whole, positive. The greatest effect is that fine mill wastes are transformed from a waste material that is usually burned or landfilled into a useful product. A small amount of fine wood dust may be emitted into the atmosphere during production, but the use of a filter system can largely eliminate such problems. Several years ago Oregon instituted very strict requirements for particulate emission from particleboard plants. The Oregon plants have been able to meet these standards, and the cost estimates given earlier include the cost of equipment necessary to meet the Oregon standards.

There is virtually no waste generated by particleboard manufacture, and no obnoxious odors are produced. The only waste generated in manufacturing is sander dust, which is collected and burned as fuel, and scrap particleboard, which is ground and and reused as a raw material. Particleboard manufacture is definitely a clean and desirable industry.

SUMMARY

Growth Projections

Total U.S. demand for particleboard is expected to continue its growth rate of about 16 percent per year. The growth in demand and production will include expansion of underlayment and industrial products and will also include new products such as medium density fiberboard and structural particleboard. No significant changes in the regional distribution of demand is expected. The forecasted demand for particleboard in the United States is:

Year	*Demand, billion* ft^2 *(3/4-inch basis)*
1973	3.6
1974	4.2
1975	4.8
1976	5.5
1977	6.4

Expansion in production capacity will be located close to mill waste supplies until the mill wastes are gone. Two or three new plants each in the South, California, the Northwest, and the Rocky Mountains will exhaust mill waste supplies within the next 3 years. New plants will then use roundwood or forest residues. Favored areas for new plants will then be the South, the west coast, and the Rocky Mountain regions.

Production Costs and Profits

The investment required for a new particleboard plant will be much the same regardless of location, but will depend on the size of the plant. Larger plants, of course, cost more than small ones, but the cost per unit of output is much less for larger plants, so that there is a strong trend toward greater size in new installations. The average size of new particleboard plants is expected to be 90,000 ft^2 of output capacity, at an average capital cost of $10.8 million.

The operating costs are also dependent on plant size, with large plants having a moderate advantage. The total cost of manufacturing particleboard, 1,000 ft^2, 3/4 inch basis, are approximately $64 ($27 for material, $22 for labor and energy, and $15 for capital and overhead).

Particleboard prices have been relatively stable compared to other wood products, but price projections are especially difficult because of the severe distortion caused by the price freeze of 1972. Conservative estimates, which exclude prices since the beginning of the price freeze, yield price estimates of $90 per 1,000 ft^2, 3/4-inch basis. At these prices, a new plant in the Northern Rocky Mountain region would have a first-year return on investment of 12 percent. If prices were 25 percent above the conservative estimate, the first-year return would be 22 percent.

Particleboard Production in the Northern Rocky Mountains

There are two operating particleboard plants in the Northern Rocky Mountain region; at Sandpoint, Idaho, and Missoula, Mont. A new medium density fiberboard plant at Columbia Falls, Mont., is just starting production. We can expect several more plants in the next few years, all using mill waste furnish. Estimates of unused mill wastes show concentrations in the Kootenai Valley of Montana and Idaho, and the Ceour d'Alene, Clearwater, and Lower Snake River areas in Idaho. New plants will be located close to the available mill wastes.

Using forest residues in place of mill wastes for particleboard will add about $3 per 1,000 ft^2 to the manufacturing cost, which makes forest residues an unattractive substitute for mill wastes. As unused mill waste becomes scarce within the next 3 to 5 years, however, we can expect that new particleboard plants will be designed to use forest residues. The new plants will be located close to either the large markets or close to heavy concentration of forest residues. The first large-scale users of forest residues will probably be in the South and on the Pacific coast. Because a plant using forest residues, located in the Northern Rocky Mountains, would have no advantage over similar plants in other parts of the country, we should expect that utilization of forest residues for particleboard manufacture in the Rockies will lag behind the rest of the Nation.

LITERATURE CITED

Bergvall, John A., and Donald R. Gedney.
1970. Washington mill survey--wood consumption and mill characteristics--1968. Wash. State Dep. Nat. Resour., Rep. 1. Olympia,.

Bruce, Richard.
1970. The economics of marketing particleboard. Proc. Particleboard Symp., Wash. State Univ., Pullman.

Crows Plywood Newsletter.
1968-1974. C. C. Crow Publications, Portland, Oreg.

Gray, James R., Mohammed A. A. El Saadi, and Cara W. Curtis.
1970. Economic feasibility of a particleboard industry in New Mexico. N. M. State Univ. Agric. Exp. Stn. Bull. 569, Las Cruces, N. M.

Host, John R., and David P. Lowery.
1970. Portable debarking and chipping machines can improve forestry practices. USDA For. Serv. Res. Note INT-122, Intermt. For. and Range Exp. Stn., Ogden, Utah.

Lambert, Herb.
1973. 1972 lumber production. For. Ind., May 29.

Manock, Eugene R., Grover A. Choate, and Donald R. Gedney.
1970. Oregon timber industries 1968, wood consumption and mill characteristics. Oreg. Dep. For. and Pac. Northwest For. and Range Exp. Stn.

Raddin, Harry A,
1970. The economics of the system producing dry process medium density fiber-board. Proc. Particleboard Symp. Wash. State Univ., Pullman.

Staepelaere, Raymond.
1971. A study of particleboard in North America and Europe through 1980. Black-Clawson, Inc., Everett, Wash.

U.S. Department of Commerce, Bureau of the Census.
1973. Current industrial reports, particleboard. Ser. MA-24L (72-1). Gov. Print. Off., Washington, D.C.

U.S. Department of Commerce, National Bureau of Standards.
1966. Mat-formed wood particleboard. Commercial standard CS 236-66. Off. Prod. Stand., Washington, D.C.

USDA Forest Service
1973. The outlook for timber in the United States. For. Resour. Rep. 20. Gov. Print. Off., Washington, D.C.

Vajda, Peter.
1970. The economics of particleboard manufacture revisited, or an assessment of the industry in 1970. Proc. Particleboard Symp. Wash. State Univ., Pullman.

☆U.S. GOVERNMENT PRINTING OFFICE: 1974 — 677-097 / 62 REGION NO. 8

WITHYCOMBE, RICHARD
1975. The outlook for particleboard manufacture in the Northern Rocky Mountain region. USDA For. Serv. Gen. Tech. Rep. INT-21, 39 p. (Intermountain Forest & Range Experiment Station, Ogden, Utah 84401.)

National demands for particleboard panel products and raw materials supply are projected for the 1970's. Expanding production is expected to shift raw material sources to forest residues. Analysis of production costs indicates that in the Northern Rocky Mountains plants utilizing forest residues cannot profitably compete with plants utilizing mill residues until existing mill residues are utilized.

OXFORD: 796, 839.84, 862.2
KEYWORDS: particleboard, waste wood uses, production studies, raw materials, wood residues.

WITHYCOMBE, RICHARD
1975. The outlook for particleboard manufacture in the Northern Rocky Mountain region. USDA For. Serv. Gen. Tech. Rep. INT-21, 39 p. (Intermountain Forest & Range Experiment Station, Ogden, Utah 84401.)

National demands for particleboard panel products and raw materials supply are projected for the 1970's. Expanding production is expected to shift raw material sources to forest residues. Analysis of production costs indicates that in the Northern Rocky Mountains plants utilizing forest residues cannot profitably compete with plants utilizing mill residues until existing mill residues are utilized.

OXFORD: 796, 839.84, 862.2
KEYWORDS: particleboard, waste wood uses, production studies, raw materials, wood residues.

WITHYCOMBE, RICHARD
1975. The outlook for particleboard manufacture in the Northern Rocky Mountain region. USDA For. Serv. Gen. Tech. Rep. INT-21, 39 p. (Intermountain Forest & Range Experiment Station, Ogden, Utah 84401.)

National demands for particleboard panel products and raw materials supply are projected for the 1970's. Expanding production is expected to shift raw material sources to forest residues. Analysis of production costs indicates that in the Northern Rocky Mountains plants utilizing forest residues cannot profitably compete with plants utilizing mill residues until existing mill residues are utilized.

OXFORD: 796, 839.84, 862.2
KEYWORDS: particleboard, waste wood uses, production studies, raw materials, wood residues.

WITHYCOMBE, RICHARD
1975. The outlook for particleboard manufacture in the Northern Rocky Mountain region. USDA For. Serv. Gen. Tech. Rep. INT-21, 39 p. (Intermountain Forest & Range Experiment Station, Ogden, Utah 84401.)

National demands for particleboard panel products and raw materials supply are projected for the 1970's. Expanding production is expected to shift raw material sources to forest residues. Analysis of production costs indicates that in the Northern Rocky Mountains plants utilizing forest residues cannot profitably compete with plants utilizing mill residues until existing mill residues are utilized.

OXFORD: 796, 839.84, 862.2
KEYWORDS: particleboard, waste wood uses, production studies, raw materials, wood residues.

Headquarters for the Intermountain Forest and Range Experiment Station are in Ogden, Utah. Field Research Work Units are maintained in:

- Boise, Idaho
- Bozeman, Montana (in cooperation with Montana State University)
- Logan, Utah (in cooperation with Utah State University)
- Missoula, Montana (in cooperation with University of Montana)
- Moscow, Idaho (in cooperation with the University of Idaho)
- Provo, Utah (in cooperation with Brigham Young University)
- Reno, Nevada (in cooperation with the University of Nevada)

AMERICAN REVOLUTION BICENTENNIAL
1776-1976

GROWING FROM '76
U.S. FORESTRY CENTENNIAL