

Small-diameter wood processing in the southwestern United States: An economic case study and decision analysis tool

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Abstract

Ponderosa pine ecosystem restoration has been proposed as a method of improving ecosystem health and lowering the risk of catastrophic wildfire in forests in the southwestern United States. There are few facilities in that region that process material removed from restoration treatments into products. At the time of this study, Alpine Trucking and Specialty Woods was an integrated small-wood processor located in Eagar, Arizona, that used logs from restoration treatments to produce roundwood products. A flow diagram was created that showed the products and by-products that resulted when a log was allocated to production of a primary product. This was converted into a spreadsheet model that included the product yields, processing rates, processing costs, and sales revenue. The primary value of this to a broader audience is in demonstrating that a useful model could be built from the working knowledge of mill employees. As a result of this study and the use of the decision analysis software, it was determined that utility poles were not a good product option for Alpine given their equipment mix because processing was inefficient, resulting in high processing costs and low or negative margins. Hand-peeled poles made large contributions to net revenue because they required little processing and carried a premium price. Alpine determined that small peeled poles were their core business and implemented in-woods sorting to route some logs directly to other manufacturers to minimize handling of logs that were not profitable for their operation. The practice of aggressively marketing by-products such as shavings, sawdust, and bagged firewood was retained as an important key to being able to gain revenue from all of the material brought to the mill.

Restoration treatments that reduce the stocking density of small-diameter trees and reintroduce fire into the ecosystem can be used to reduce the risk of fires that threaten existing structures and to improve forest health. These treatments typically remove most of the trees that are 20.3 cm (8 in.) diameter at breast height (DBH) and smaller and some larger trees. Although restoration may prove effective in improving forest health and reducing fire risk, the costs of these treatments can be substantial. Ecological restoration of ponderosa pine (*Pinus ponderosa* var. *scopulorum*) forests is a potential economic problem because of the low value of wood fiber removed and the high cost of removal. Harvesting and thinning small-diameter trees can be

costly and uneconomical because of the lack of existing markets for the removed material (Mirth and Larsen 1997).

In this study, a small-diameter roundwood operation was modeled by using their production information, and an analysis tool was created. The intent of this tool was to aid the manufacturer in making business decisions and to provide insights about the attributes that

contribute to profitable manufacture of products from small roundwood. This paper provides more complete economic information on the uses for small-diameter wood needed by decision makers involved in managing fire risk, such as stumpage prices necessary for local contractors to profit. Although a better understanding of what is important to a processor of small roundwood may

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Figure 1. — Viga latilla ceiling. Vigas are the larger diameter poles and latillas are the smaller diameter poles.

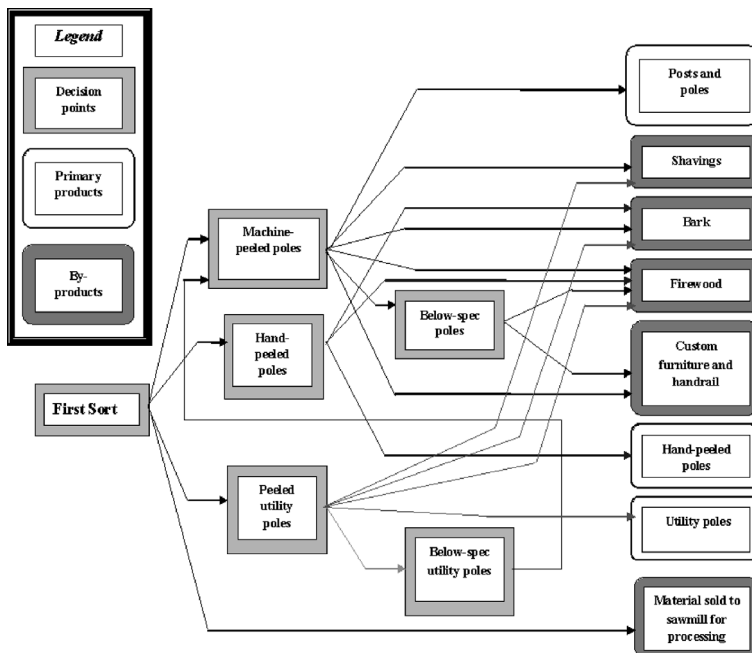


Figure 2. — Alpine Trucking and Specialty Woods materials balance flow chart.

help resource managers prepare sales better suited to meeting customer needs as well as ecosystem goals, this should be viewed as a niche market for a small part of the volume that could be generated from restoration treatments. This paper may also be useful to entrepreneurs who want information on the operation of small-diameter-roundwood processing facilities or on using their knowledge in an analytical way.

Alpine Trucking and Specialty Woods was an integrated small-wood processor in the Southwest. They were located in Eagar, Arizona, and were one of very few facilities capable of effectively using small-diameter material in that region. Alpine innovated new products to accommodate changing markets in the Southwest and utilized the by-products of production in the sale of bagged firewood, bark, and wood shavings. Al-

pine's roundwood peeling operation processed mainly ponderosa pine from ecological restoration treatments and fire reduction thinnings. Alpine bought stumpage, harvested and transported timber to their mill, and made a variety of roundwood products.

Alpine's primary products were hand-peeled poles, machine-peeled poles with or without a hand-peeled finish, and utility poles. One of the markets for these poles is viga latilla ceilings, which are common in Southwest architecture (Fig. 1). The by-products marketed were custom furniture, handrails for stairs and decks, firewood, bark for landscaping, and shavings for animal bedding.

Methods

Spreadsheet-based models have been recognized as powerful analysis tools in modeling mill operations (Mendoza et al. 1991) and other applications, such as forest production planning (Davis et al. 1990, Leefers and Robinson 1990). A spreadsheet cost model of the roundwood peeling process was created in this study by using cost, revenue, and production information provided by Alpine. No production studies were used to obtain this information; rather, the model was created by taking known production information and systematizing it. In a generic way, our approach is similar to those used by others (Allen and Schuster 2000, Watts 2000).

Materials balance flow chart

The first step in modeling was to create a materials balance flow chart of Alpine's production process. The flow chart was created in a way that volumes of logs could be accounted for in the production of primary products and by-products (Fig. 2). The flow chart represents the flow of logs through the production process and the various primary products and by-products that can be produced with a given set of logs. Primary product paths are driven by characteristics of logs. Lines in this flow chart are associated with the amount of product being created and the costs and revenues attributed to that step in the production process.

The flow chart begins with logs that are brought into the processing yard and are then bucked and sorted into three categories for processing: posts and poles, hand-peeled material, or utility poles depending on ranges of log sizes

Table 1. — Break-even cost for a sample log 6 inches in diameter on the small end and 15 feet long that could have been processed by hand or machine.

Primary product	Gross revenue	Machine-peeling cost	Hand-peeling cost	Yard-handling cost	By-product production cost	Break-even cost
----- (\$/ft. ³) -----						
Hand-peeled pole	8.42	0.00	1.09	0.00	0.02	7.31
Machine-peeled pole	4.37	1.03	0.00	1.29	0.03	2.02

Table 2. — The average break-even cost for a sample of 46 logs that could have been machine-peeled, or machine-peeled with a hand-peeled finish.

Primary product	Break-even cost (\$/ft. ³)
Machine-peeled pole with a hand-peeled finish	1.31
Machine-peeled pole	0.96

that can be used to produce these products. Logs that cannot be used for any of those products because they are too large to be processed at this facility are sold to a local sawmill operation. Finally, partially processed material becomes primary products or by-products. The cost model was built with this general conceptual layout in mind along with the application of production information, cost, and pricing calculations that were made with information provided by Alpine personnel.

Production information

Employees at Alpine provided production information on initial sort criteria used to separate incoming raw logs into subgroups of logs that could be used to process different primary products. This information was in the form of ranges of log characteristics including small- and large-end diameters, sweep, average knot size, and length. Production information also included estimates of average proportions (by volume) of processed logs that went to by-products including bark and shavings, and percentage of finished material that did not meet grading specifications and had to be reprocessed.

Cost calculations

All costs were calculated as variable costs by applying yard handling costs and processing costs to handling and processing times for each primary product. All costs were assigned to the primary products except where a by-product required subsequent processing steps. There is an important guiding rule applying these costs to products. The

factor that constrains the total output of the mill is the handling time involved in moving logs from one processing step to the next. The appropriate guiding principle in allocating costs is therefore that cost be allocated to products in proportion to the amount of handling time they require. Processes such as hand peeling were not assigned a yard handling cost because they required a minimal amount of handling. Reducing the amount of logs hand peeled would not free up handling time and would therefore not result in increases in the production of other products. A direct result of this is that net revenues for products that involved hand peeling tended to be high. Overhead for office functions and sales were not considered in this analysis.

Pricing calculations

Primary products are priced on a linear-foot basis. Prices differed by diameter for all primary products, except those sorted to produce latillas or utility poles. In those cases, prices were applied to grading classes. Grading classes for utility poles differed by length and diameter, whereas grading classes for latilla material differed only by length. Prices were applied per cubic foot of solid wood for all by-products.

Results

The break-even cost represents the maximum amount that could be paid for the logs without losing money. If the break-even cost exceeds the cost of buying the logs, the difference is profit; if the break-even cost is less than the cost of buying logs, the difference is a contri-

bution to cover fixed costs and profit; if the break-even cost is less than the cost of buying the logs, the difference is a loss (Table 1). Hand-peeled posts and poles made large contributions to net revenue because they required little processing and carried a premium price. A sample log that could have been processed as various primary products shows the break-even cost for hand peeling to be \$7.31/ft.³, whereas machine peeling the same log shows a break-even cost of \$2.02/ft.³

A hand-peeled finish could also have been applied to a previously machine-peeled log. The addition of a hand-peeled finish would give more exact final product dimensions than a completely hand-peeled pole while maintaining a hand-peeled appearance. The process of hand peeling adds value to posts and poles with little extra processing cost.

For a sample of 46 logs, the average break-even cost for machine-peeled poles was lower without the addition of a hand-peeled finish (Table 2). The average break-even cost for machine-peeled poles was \$0.96/ft.³, whereas the average cost for the same material with a hand-peeled finish was \$1.31/ft.³ It was necessary to average costs to show the effect of the addition of a hand-peeled finish because hand peeling reduces log diameter and has a negative effect on break-even cost on some logs and a positive effect on others.

Alpine implemented in-woods sorting to route some logs directly to other manufacturers to minimize handling of material that was not profitable for their operation. Logs that were unprofitable had large-end diameters either too large or too small to effectively run through peelers, were less than 6 feet in length, or had large knots. Alpine could not use logs with diameters that exceed 16 inches on the large end. Logs of that size slowed production because they would not go through automatically and had to

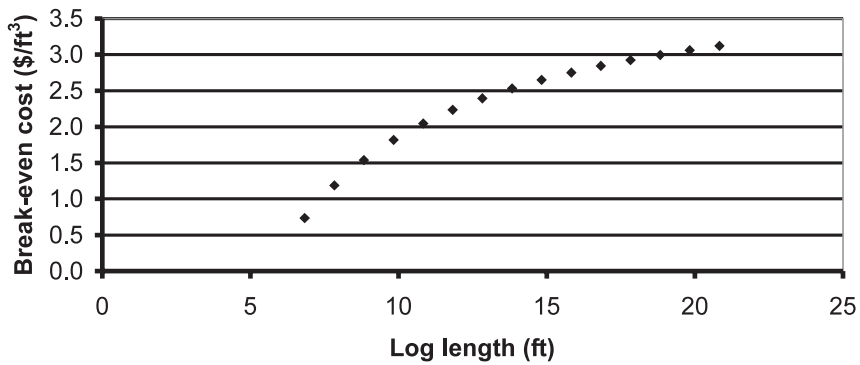


Figure 3. — Break-even cost against length for 7-inch-diameter, machine-peeled poles. Processing time is primarily related to the number of pieces run through peeling equipment and is relatively insensitive to length, but value is strongly related to length.

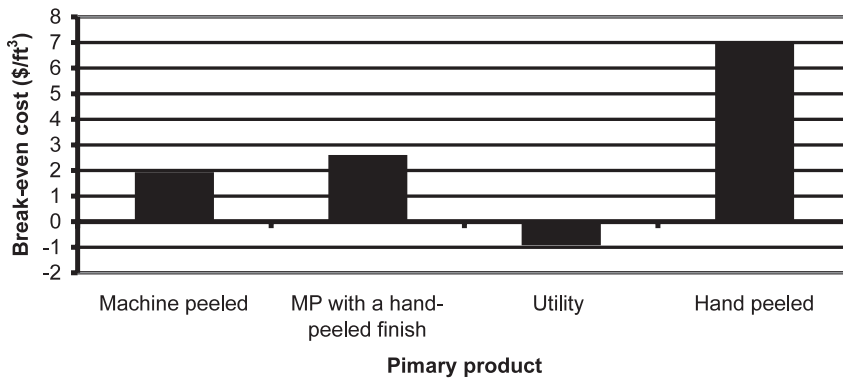


Figure 4. — Break-even cost for a log 9 inches in diameter on the small end and 19 feet long with four possible product allocations.

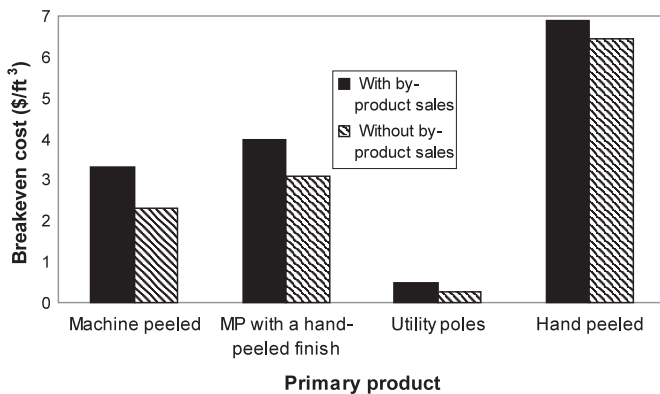


Figure 5. — Break-even cost, with and without by-product sales, without yard overhead on a log 9 inches in diameter on the small end and 19 feet long, applied to four primary product allocations.

be manually pushed through the peelers with loading equipment. This was time consuming and required labor and machinery that increased costs. Manually forcing logs through peelers also increased the risk of breaking peeling blades, causing down time and further increasing costs. Logs that exceeded 16 inches in large-end diameter could have been hand-peeled, but the demand for hand-peeled material of that size was limited or unexplored by Alpine at the time of this study.

Logs with small-end diameters less than 2.5 inches were also not profitable. That material was too small to run through peelers because it tended to break in machine processing. Material that was less than 6 feet in length was too short to run through peeling equipment, and because material was sold by the linear foot, break-even costs also dropped sharply for short lengths, as shown in **Figure 3**. Processing time is primarily related to the number of pieces run through peeling equipment and is relatively insensitive to length, although value is strongly related to length. This effect is also true of log sorting and other small-log handling and processing operations. Production is controlled by piece count rates and less so by volume or length.

Logs with large knots also could not be used by Alpine and were sent to other processors. Material with knots that exceeded 5 inches in diameter on average would slow or break peeling equipment.

Alpine also determined that utility poles were not a good product option for them given the current equipment mix because processing was inefficient. **Figure 4** illustrates this point by comparing break-even cost with different product allocations of a log 9 inches in diameter on the small end and 21 feet long. Utility poles yield the lowest break-even cost of any product allocation. This result does not imply that there is not an opportunity to profit from the sale of utility poles given proper processing equipment.

Marketing by-products such as shavings and bagged firewood was retained as an important element of gaining revenue from all processed material at the mill. Profitability of many primary-manufacturing operations depends on positive returns from residues. This effect is often the difference between profitable and unprofitable product options.

The break-even cost calculated on a single log that could have been processed as a hand-peeled, machine-peeled, machine-peeled with a hand-peeled finish, or a utility pole showed an average decrease of 24 percent without the sale of by-products (Fig. 5). It is important to note that these calculations of net revenue with and without by-product sales did not take into account costs associated with waste disposal. Including disposal costs would have increased the differences in net revenue calculations because there would have been an excess of waste material if by-products were not sold.

The volume of waste that could be expected when producing the four products in the last example is on average 48 percent of the total log volume. Broken down by product type, the proportion of waste volume to log volume is 47, 53, 64, and 28 percent for the production of machine-peeled, machine-peeled with a hand-peeled finish, utility, and hand-peeled poles, respectively. These volume calculations show the importance of aggressively marketing by-products because these volumes must be dealt with by their sale or disposal.

Summary

Understanding the production of products from small-diameter logs that

come from ecological restoration fuel-reduction thinnings will be an important component of funding those treatments in the future. The model presented in this study addresses several areas of small-diameter post and pole production. It can be used in many ways, such as a tool for look-ahead scenarios for different production schedules and the design and analysis of alternative production systems. It was used to demonstrate break-even costs and net revenues for a processor of small-diameter material, pointing out the strengths and weaknesses of their production process.

Use of this model on the Alpine Trucking and Specialty Woods operation showed that systematizing information changed management decisions and possibly increased revenue. The production of utility poles was shown to have negative net revenue in all cases. Production steps that added value to logs with little extra manufacturing cost, such as the hand peeling of posts and poles, were shown to make large contributions to net revenue. The model also demonstrated the importance of marketing by-products where their sale would both increase revenue and decrease disposal costs. The primary value of the numbers shown here is that they demonstrate two things about the approach: 1)

it is possible to build a credible model based on the working knowledge of people running a business; and 2) systematizing this information can identify decisions that can considerably affect mill revenue.

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