Influence of edging practices on cutting yields of Alaska birch lumber

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Abstract

Birch lumber is often characterized by a high degree of knots, bark pockets, heartwood, and other features which force sawmill owners to decide whether to edge and trim boards to produce standard grade lumber vs. proprietary grade character-marked lumber. In addition, the edging strategies used with irregularly shaped flitches can greatly influence cut-stock recovery. To investigate this recovery, 143 kiln-dried 4/4 birch flitches were obtained from a sawmill in south-central Alaska and evaluated by a National Hardwood Lumber Association (NHLA) grader for board grade and lumber tally. Each flitch was marked by the lumber grader, indicating where the board would be edged to produce NHLA grade lumber in a production setting. The flitches were transported from Alaska to Oregon State University where they were scanned to produce digital board data. These data were then processed with the computer simulation program CORY (Computerized Optimization of Recoverable Yield) to estimate the cut-stock yield for various levels of edging severity and sound feature (character mark) inclusion.

Four edging strategies were evaluated, ranging from unedged (least severe) to wane-free (most severe). As expected, cutting area recoveries and cutting yields were reduced as edging severity was increased. In many cases, however, these differences were minimal. Cutting yields for clear parts were 21.1, 23.7, 26.2, and 27.1 percent for wane-free, actual, light, and unedged strategies, respectively. Cutting yields for parts that included sound character features increased by more than double to 44.0, 49.0, 52.7, and 54.0 percent for wane-free, actual, light, and unedged strategies, respectively. These results indicate that finding value-added alternatives for this character-marked birch might prove profitable for some Alaskan sawmills that also produce secondary products such as cabinets and furniture or supply cuttings to these manufacturers.

The birch (*Betula papyrifera* Marsh.) resource in Alaska is prevalent, including close to 100 million cubic feet of young sawtimber growing stock on about 140,000 acres in south-central Alaska (Campbell et al. 2005). Despite this substantial resource, birch lumber production in Alaska is limited to just a few sawmills. There is generally strong interest in birch products among lumber producers and retail store managers in Alaska (Nicholls 2002). But, there are major obstacles to its widespread use including obtaining dependable log supplies, achieving consistent moisture content (MC) in kiln-dried lumber, and matching appearance and character features to desired end products.

Lumber sawn from birch often has relatively large proportions of heartwood, which is considered a defect under the National Hardwood Lumber Association (NHLA) grading rules (NHLA 2003). Consequently, its boards provide too few clear (i.e., defect free) cuttings of adequate size to produce higher grade lumber. Further, decay is common in Alaska birch. One study which involved dissecting 600 birch trees grown in Alaska found that only 10 percent lacked decay and virtually all included at least some natural stain (Trummer 2001). While the more valuable grades of lumber require large proportions of clearwood, the increasing popularity of rustic style products may favor inclusion of character features such

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as heartwood, small-sound knots and bark pockets, and stain. Among these products are birch kitchen cabinets, which were found to have strong consumer acceptance when character features such as knots and bark pockets were included (Donovan and Nicholls 2003).

Edging practices greatly influence lumber grade and profitability because under standard NHLA rules, wane allowance is as much a factor in determining grade as other features such as knots, holes, stain, mineral streak, decay, splits, and checks (NHLA 2003). The Alaskan sawmills processing birch find it difficult to produce the higher lumber grades in quantities sufficient to justify investing in optimizing edgers, machines designed to maximize allowable wane and, consequently, value. Therefore, they must rely on trained operators to manually edge their boards, which is a practice that has been shown to produce less than maximum value much of the time (Flann and Lamb 1966, Bousquet 1989, Kline et al. 1991, Regalado et al. 1992, Schmoldt et al. 2001).

A larger market, such as trading proprietary lumber grades developed specifically to satisfy the needs of secondary manufacturers producing rustic style products, might justify the production of more birch lumber and automated processing. Such a proprietary market exists for red alder lumber in the Pacific Northwest, but it takes the cooperation of both producers and sellers to be developed. Along with determining the type and size of sound features to include in a proprietary grade, the issue of wane allowance is also important because edging practices have been shown to greatly affect cutting-stock yields (Beaudoin et al. 1982, Brunner et al. 1996). Wengert and Lamb (1990) estimated that each additional sixteenth of an inch reduction in edging resulted in an increase in yield of 1.5 percent.

In practice, optimum edging is a complex decision-making process that requires trained mill personnel to quickly evaluate board grade, value, surface measure, and trimming allowances. Schmoldt et al. (2001) estimated that human operators make optimal decisions only 62 to 78 percent of the time, while Regalado et al. (1992) found that edging and trimming operations at three hardwood mills produced only 65 percent of the lumber value possible with optimal edging practices. Kline et al. (1991) found that the greatest loss in value occurred when non-optimal edging reduced potential First and Second (FAS) boards to No. 1 Common grade. They also found that lumber volume increased at two hardwood sawmills by 17 and 23 percent with optimum edging and trimming, respectively.

One common finding of edging optimization research has been that even relatively minor changes in edging practices can influence both volume and value recovery of lumber. Brunner et al. (1996) found that the change (vs. normal mill practice) in cut-stock volumes of red alder lumber ranged from a 7-percent decrease to a 13-percent increase depending on the degree of edging. In that study, more high-value, longer cuttings were produced at the higher recovery levels. Kline et al. (1993) found that furniture parts produced from unedged and untrimmed material resulted in volume gains of up to 25 percent vs. actual edging as practiced by mills. Other studies have shown a potential for increasing hardwood lumber value by more than 20 percent through optimum edging and trimming (Bousquet 1989). The financial impact of proper edging can be substantial. In a vertically integrated hardwood mill producing 20 million board feet (MMBF) of lumber per year, annual income could be increased an estimated $2 million through optimum edging practices (Brunner et al. 1996).

Clement et al. (2005) investigated alternative edging practices for processing short logs as a means of increasing the utilization of the white birch (*Betula papyrifera* Marsh.) resource in Quebec, Canada. While they did not investigate edging practices or overall lumber recovery, they concluded that higher furniture part yields were obtained with conventional vs. short-log processing. But, differences were minimized by selecting appropriate cutting bills for each processing alternative.

Given the findings of past research and the challenges of economically processing birch lumber in Alaska, the research reported in this paper is an attempt to consider ways of improving utilization of this resource. The objective was to determine what degree of edging severity (based on four scenarios), when applied to a sample of Alaska birch lumber, would result in the greatest lumber yield under NHLA grading rules. A secondary objective was to consider the influence on cutting areas and cutting yields of allowing specific sound defects.

Materials and methods

Sample material

In this study, 143 kiln-dried, unedged birch flitches were obtained from a sawmill in south-central Alaska. The Alaska birch trees harvested to produce these flitches were located approximately 60 miles north of Anchorage, Alaska, and trees averaged about 60 to 80 years of age. All of the flitches were nominally 8 feet long. Flitches were graded by an NHLA grader into four NHLA grades, with the greatest proportion being No. 3A Common. The grader also marked each flitch with edging lines indicating the board's width when edged to obtain maximum grade. These widths ranged from 4.0 inches to more than 9.0 inches, with a relatively uniform distribution. **Table 1** provides details on volume and width distribution by grade. The flitches were then transported from Wasilla, Alaska, to the Department of Wood Science and Engineering at Oregon State University, Corvallis, Oregon, where they were imaged for further study.

Table 1. — Distribution of Alaska birch flitches by board width and grade.

	Number of boards, by grade				
Width class[a]	No. 1 Common	No. 2 Common	No. 3A Common	No. 3B Common	Total
4.0 to 4.9	5	1	12	3	21
5.0 to 5.9	4	1	9	0	14
6.0 to 6.9	3	8	12	3	26
7.0 to 7.9	3	6	10	3	22
8.0 to 8.9	2	4	8	8	22
9.0 to 9.9	2	5	4	11	22
10.0 and greater	0	7	8	1	16
Total number of boards	19	32	63	29	143
Percent of total	13.3	22.4	44.1	20.2	100

[a]Board grades and widths as determined by NHLA certified grader under normal edging practices.

Board data collection

A computer-controlled imaging system, consisting of a Hitachi HV-C20 CCD color camera mounted on a linear track and connected to a Truevision TARGA+ image capture board was used to create coordinated image data for both sides of the boards. The imaging system's spatial resolution was 15 pixels per inch across the flitch width and 11.25 pixels per inch along the flitch length. Software developed at Oregon State University was used to extract feature data from the boards such as board shape and defect size, type, and location. The data set was then used as input to a simulation program to estimate cut-stock yields for various edging practice and cut-stock quality combinations.

Cut-stock simulation

A three-stage, rip-first, fixed-width, random-length version of the CORY (Computerized Optimization of Recoverable Yield) board cut-up program (Brunner et al. 1989, Anderson et al. 1992) was used to determine the volume of cut-stock parts that could be produced from the imaged flitches. The cutting bill included fixed widths of 1.5, 2.0, 2.5, and 3.0 inches, while the random lengths ranged from a minimum of 6 inches to a maximum of 38 inches. Lengths longer than 38 inches were sawn into two parts to reach an acceptable size.

Four different edging strategies were evaluated using CORY simulations. The unedged strategy retained the entire flitch as imaged. Light edging produced edges that were at least one-third of a flitch's length, which given the nominal length of the flitches created the potential to have a contiguous clear edge matching the maximum clear cutting length of 38 inches. The actual edging strategy used the area inside the NHLA grader's marks; the wane-free strategy removed all wane.

The birch lumber from this part of Alaska contains significant amounts of sound natural features, such as heartwood, tight knots, sound rot, and sound insect damage. With the market for rustic-style material increasing, several scenarios that take advantage of this material's natural character were created to estimate the added yield from producing rustic cut-stock instead of the typical clear cut-stock. The clear cutting scenario consisted of normal clear, two-face parts with both faces completely free of defects. Three rustic grade scenarios were designed to produce cut-stock with increasing amounts of sound defects. The first scenario accepted tight knots, the second accepted heartwood, and the third accepted tight knots, heartwood, and sound incipient decay and insect damage.

The edging strategies and cut-stock scenarios resulted in 16 simulated production runs, one for each possible combination. Results were compiled for each grade, and the individual and average cutting yields were calculated.

Results and discussion

Average cut-stock yields

Figure 1 shows the percent area yields averaged across all of the grades for the 16 combinations of simulated edging strategies and cut-stock qualities. **Table 2** lists these same yields for each edging strategy. The yield is not identical to that used in industry because the calculations in **Table 2** are based on the edged board's bounding box area (the board's maximum width times its maximum length) and not a grader's estimated surface measure. The yields for the wane-free and actual edging strategies probably approximate those based on a grader's calculations, but the light and unedged would not. While not a true measure of available board area, the bounding box provides a relative measure of the board area that must be processed and is a very good indicator of the board volume occupying a dry kiln. Because the base area becomes smaller as edging severity increases, percent yields increase as more non-usable wane is removed. This can be viewed as improving board conversion efficiency, but at the same time wane is removed so is usable wood, resulting in a loss of cut-stock. **Figure 2** shows how edging strategy and cut-stock quality affect the amount of cut-stock that can be produced from the same board resource. Both views give useful insight into rough mill processing and production but from very different perspectives.

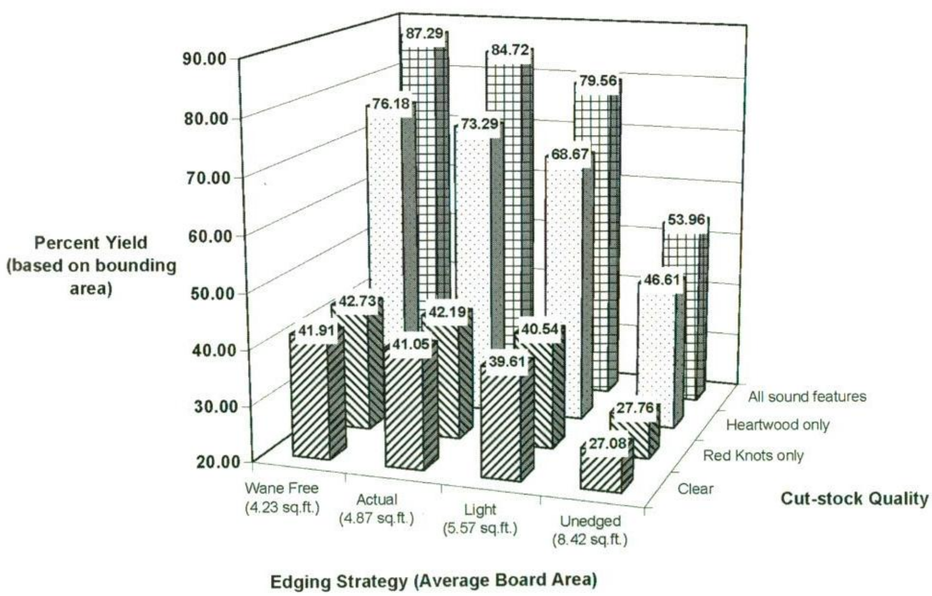


Figure 1. — Average yields for all grades by edging strategy and cut-stock quality.

Relative cut-stock production and edging strategies

Perhaps a more understandable approach is to compare cut-stock production against a constant base. The most obvious choice is to use the grader's edging marks, or actual edging strategy, because it more closely represents typical industry practice. **Figure 3** shows how much of each edging strategy's marginal board area is converted to cut-stock. Marginal area is calculated by subtracting the actual edging strategy's bounding area from an alternative edging strategy's bounding area. Then, this number is divided into the gain or loss in cut-stock from the actual edging's cut-stock production and converted into a conversion efficiency percentage. **Table 2** lists the conversion efficiency for every

Table 2. — Cutting yields and conversion efficiencies by edging strategy and type of sound features allowed.

Defects allowed	Edging strategy	Area yield	Change in cutting area	Conversion efficiency
		----------	(%)	----------
No defects allowed	Unedged	27.08	14.07	8
	Light edging (to at least 1/3 wane-free)	39.61	10.48	30
	Actual edging (marked by grader)	41.05		41
	Wane-free	41.91	−11.28	−35
Tight knots allowed	Unedged	27.76	13.79	8
	Light edging (to at least 1/3 wane-free)	40.54	10.03	29
	Actual edging (marked by grader)	42.19	- -	42
	Wane-free	42.73	−11.62	−38
Heartwood allowed	Unedged	46.61	9.97	10
	Light edging (to at least 1/3 wane-free)	68.67	7.28	37
	Actual edging (marked by grader)	73.29	- -	73
	Wane-free	76.18	−9.30	−53
Heartwood, tight knots, incipient rot, and insect damage	Unedged	53.96	10.14	12
	Light edging (to at least 1/3 wane-free)	79.56	7.53	44
	Actual edging (marked by grader)	84.72	- -	85
	Wane-free	87.29	−10.09	−67

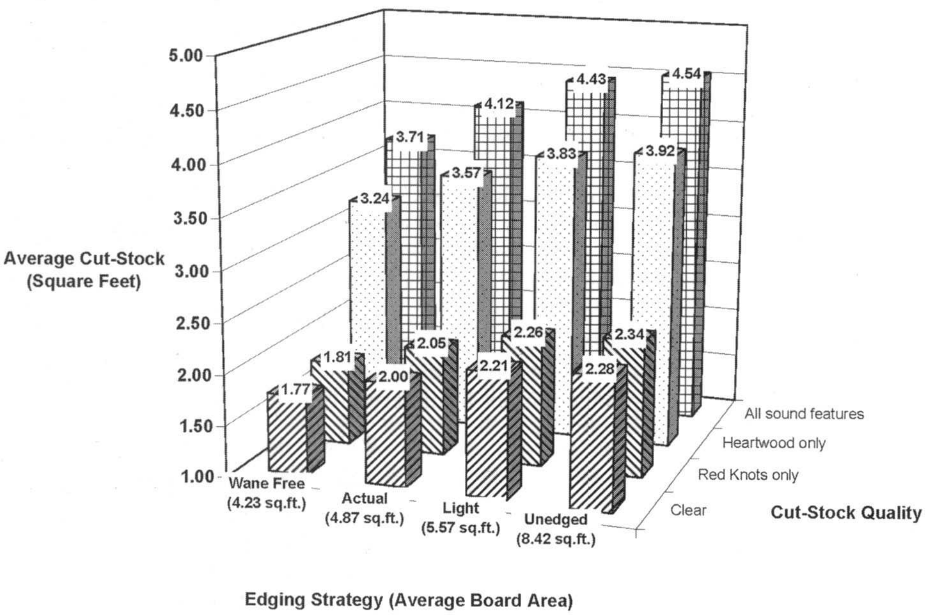


Figure 2. — Average cut-stock production by board edging strategy and cut-stock quality.

combination of edging strategy and cut-stock quality. It also shows the percent gain or loss in cut-stock compared to the amount produced by the actual edging strategy.

Relative cut-stock production and cut-stock quality

Figures 1 through 3 and **Table 2** show that cut-stock quality had an even greater effect on production than the edging strategies. Adding allowable features obviously translated into more usable wood to be converted into cut-stock. With the actual edging strategy, accepting tight, red knots resulted in only a small increase in recovery, which is not surprising given that they occupy only 1 or 2 percent of board area. Accepting heartwood into a rustic cut-stock resulted in almost a doubling in production, and accepting all sound features produced more than twice the amount of cut-stock as the clear category. The effect of the unedged strategy on cut-stock production had similar patterns, regardless of the quality of the cut-stock, but the light and wane-free edging strategies exaggerated results even more as additional sound features were allowed. When all of the sound defects were allowed, light edging resulted in almost half of a square foot of cut-stock for every added square foot of bounding area, while wane-free edging lost two-thirds of a square foot. These results are not surprising given that heartwood accounted for 3 to 30 percent of board area depending on lumber grade. Therefore, once it was allowed, most wood left or removed from a board was likely to become cut-stock.

Relative cut-stock production and board grade

The pattern of changing cut-stock production with board grade and edging strategy is fairly consistent across the four cut-stock categories. The change in production for No. 1 Common increased more with unedged strategy than the other grades, while No. 2 Common increased the least. The No. 3 Common grades were usually somewhere between No. 1 and No. 2. This is most likely due to the distribution of widths by grade as well as the specific grading rules regarding wane.

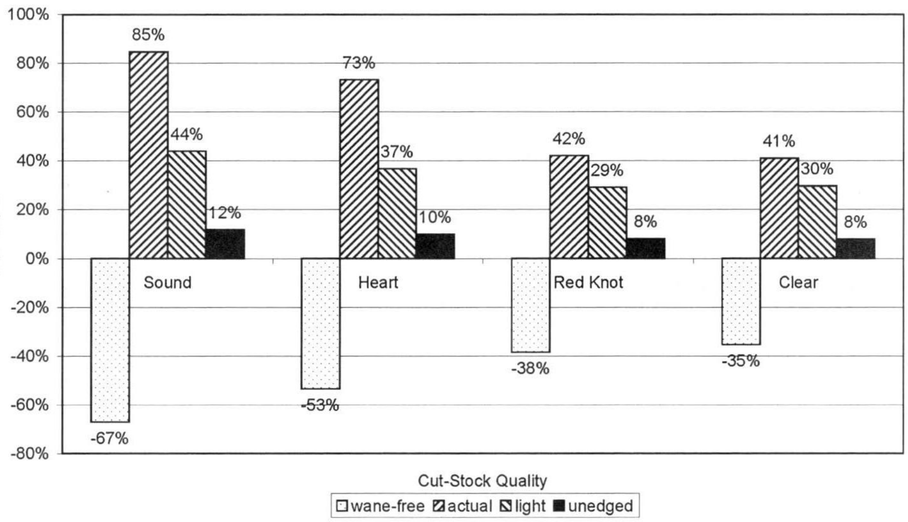
Cut-stock production and board width

Board width played a role in cutting yield, but it was not consistent (**Figs. 4 and 5**). This was especially true for the case where only clear, two-face parts were allowed and may be due to the fact that the fixed-width version of the CORY program was used. This created the potential for various board widths to have a greater opportunity for allowing different combinations of fixed widths to fit. When all of the sound features were allowed, however, the trend was clearer that wider boards produced higher cutting yields for each edging strategy. Edging strategy also had an effect for each board width, but the benefit was reduced as board width increased.

Conclusions

Producing cut-stock parts from birch lumber from south-central Alaska represents a viable option for creating high-value wood products from clear cuttings. Due to the high proportion of features found in birch,however, edging strategies that optimize the tradeoffs between defect features and lumber value should be considered. Key considerations for Alaska wood products firms often include how much character and what types of features to include in birch lumber for different products. This study found that heartwood and wane were, by a wide margin, the two most important features affecting the recovery of cut-stock parts from this sample of birch lumber. Cut-stock yields were substantially higher when sound defects such as heartwood, sound rot, tight knots, and sound insect damage were allowed.

This study also found that edging practices, ranging from unedged to wane-free strategy, had a great influence on this material's cutting yields. It appears that a light edging strategy could substantially increase cut-stock production over actual or wane-free edging strategies. But, the secondary wood products industry in Alaska has raw material requirements and processing equipment that may differ significantly from that of larger hardwood sawmills. Most hardwood producers in Alaska do not currently sell lumber based on NHLA grading rules but rather rely on customer preferences (without any formal grading system).



* Actual edging numbers reflect actual board area converted to cut stock.

Figure 3. — Cut-stock produced or lost as bounding box area is added or removed from the actual edging bounding box based on sound features allowed and edging strategy.

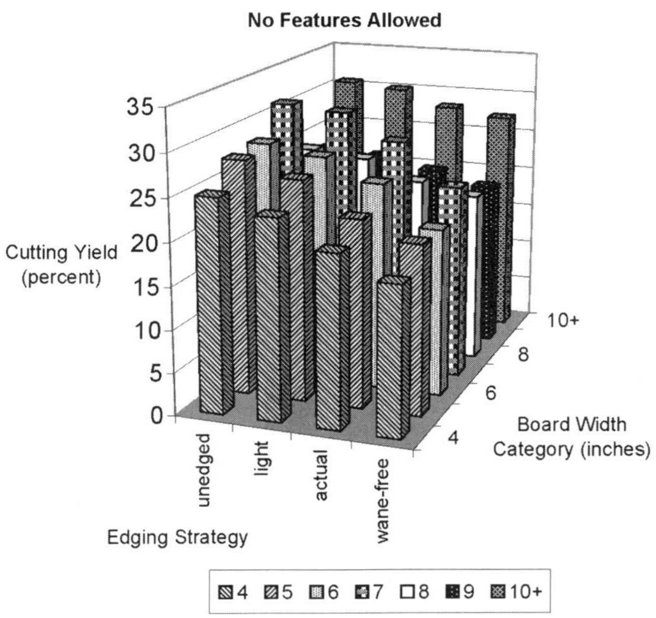


Figure 4. — Cutting yields by board width for all board grades combined using four edging strategies and allowing only clear, two-face parts. Yield percentages are based on the no (none) edging strategy board area.

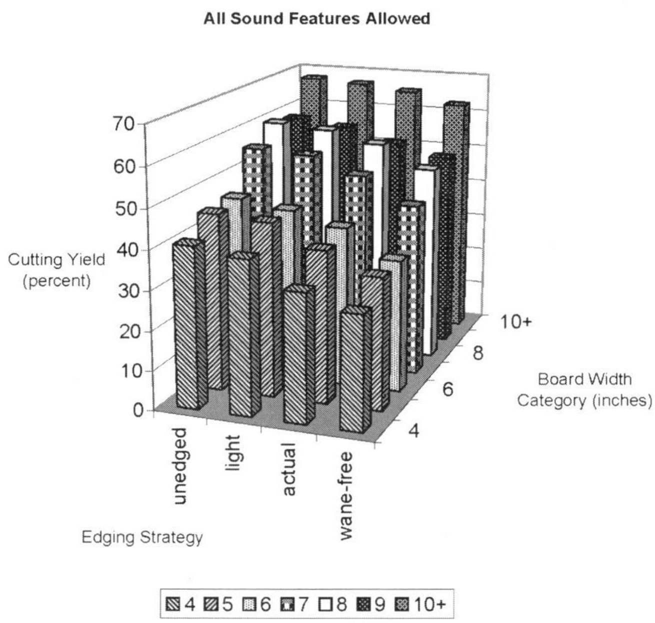


Figure 5. — Cutting yields by board width for all board grades combined using four edging strategies and allowing parts to contain all sound features. Yield percentages are based on the no (none) edging strategy board area.

Further, most producers edge lumber based on criteria other than maximizing volume. For example, a common practice is to remove all wane for use in products such as paneling, flooring, and mouldings. This practice should be reconsidered when producing cut-stock parts where some wane may be advantageous in terms of yield. The development of new grading rules for Alaska birch lumber could actually benefit cut-stock production and value, particularly if rustic grades were established. This scenario would be similar to the highly successful path followed by red alder lumber markets in the Pacific Northwest. Sawmill expansion to the scale needed for cut-stock part production in Alaska could allow sawmills to produce a variety of cuttings for products such as furniture, panels, and flooring.

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