

Consumer and manufacturer perceptions of hardwood panels made from character-marked lumber

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Hardwood panels made from edge-glued material are a versatile product that could be within the reach of many smaller wood products firms. However, products would need to be accepted throughout the supply chain for this opportunity to be achieved. This study evaluated preferences of consumers and manufacturers towards edge-glued panels from Alaskan red alder and paper birch. A total of 11 panels were constructed, including different levels of character-mark features such as knots and natural stain. We found strong preferences for the birch panel having high levels of natural stain. This panel was also the highest rated panel on three attributes (character marks, grain consistency and overall colour). Both residential consumers and wood products producers preferred birch panels featuring natural stain to birch panels featuring knots. Both groups also preferred red alder panels that were either clear or with high levels of character (but not intermediate levels of character). Residential consumers favoured birch panels (versus red alder panels) to a greater extent than did wood product producers and generally were less familiar with red alder than were producers.

Keywords: Edge-glued panels, Character marks, Alder, Birch

Introduction

Edge-glued panels represent a product opportunity within the technical and financial reach of many smaller manufacturers. Edge-glued panels can be manufactured for a variety of specific end uses such as furniture and kitchen cabinets, or made as standard-sized blanks (Araman 1983, Bowyer *et al.* 1986). Production of edge-glued panels could become a natural extension for the paper birch (*Betula papyrifera* Marsh.) and red alder (*Alnus rubra* Bong.) lumber industries in Alaska, allowing producers to explore a wider variety of products and markets. Edge-glued panel production could represent an important niche-product opportunity for producers in Alaska and elsewhere.

Advantages of edge-glued panel production include the relatively low cost of equipment, the potential use of smaller diameter stems and/or lower grades of lumber, the flexibility in panel sizes, and opportunities to sell within established local markets. In the US, red alder is a common species for furniture manufacture, yet is still a lesser-known species in most consumer markets. Very little red alder lumber currently is produced in Alaska,

although a viable resource base exists (Brackley *et al.* 2009). In Europe, common alder (*Alnus glutinosa* L.) has economic importance for use as pilings, furniture, smoking chips and specialty products such as clogs. Also in Europe, two birch species (*Betula pendula* Roth and *B. pubescens* Ehrh.) are the most utilised hardwoods in Finland. These woods are frequently used for furniture manufacture due to their hardness and relatively low density (Luostarinen and Möttönen 2009). The veneer and plywood industries in Finland typically use up to 1.5 million cubic metres of birch per year (Verkasalo 1997), while birch lumber production typically ranges from 50 000 to 100 000 cubic metres per year (Sevola 1998, Luostarinen and Verkasalo 2000).

Both paper birch and red alder are small diameter hardwoods, with rotation ages typically about 80 years or less in the United States. Thus, much of this resource has high levels of knots and other character mark features. Kiln-dried, planed birch lumber from interior Alaska, and red alder harvested from southeast Alaska, were the source materials for constructing edge-glued panels in this research study assessing the perceptions of two important links in the value chain for such products – manufacturers and consumers. If the production of edge-glued panels is to become a utilisation opportunity for these resources, the perceptions of multiple links in the supply chain will be important. Brinberg *et al.* (2007) and Bumgardner *et al.* (2009), for example, have shown that retailers and consumers use a different set of cues to evaluate wood household furniture. The present study investigates wood

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products producers and end consumers along several dimensions important to perceptions of hardwood products.

Factors affecting perceptions of wood products

Several studies have investigated appearance-based perceptions of wood products. Bigsby *et al.* (2005) evaluated consumer preferences for wood in furniture, considering 17 combinations of species and applied stain. They found that colour and grain were key wood attributes used by consumers to form preferences. These attributes also were among those used by Brinberg *et al.* (2007) to measure the effects of several attributes on willingness-to-pay evaluations for wood household furniture, with grain consistency and character-marks emerging as important cues. Similarly, Swearingen *et al.* (1998) found that knots were a desirable feature for those preferring bigleaf maple (*Acer macrophyllum* Pursh), whereas grain variation was favoured by those who preferred Oregon white oak (*Quercus garryana* Douglas ex Hook.). In addition to illustrating the importance of character-marks and grain to wood products perceptions, another implication of this work is that different types of wood features might elicit different evaluations depending on the context in which they are used.

Broman (2001), in evaluating the aesthetic properties of wood using knotty wood surfaces from Scots pine (*Pinus sylvestris* L.), found that the degree of 'harmony' versus 'activity' was an important theme. It was suggested that consumer preferences were based on a preferred blend of wood features, a wide variety of knot size, knot frequency, and natural colour variation in the wood samples. Previous research by Broman (1995) found that people can perceive wood based on a mixture of five feature-properties: texture, knots, colouration, contrasts and 'other' properties.

Donovan and Nicholls (2003) found that distinctive character-marks on birch cabinet doors could command a price premium, and that they may appeal to a smaller proportion of the population than would doors having less distinctive or fewer character marks. In general, doors having high levels of grain variation and those having high levels of character-marking were most appealing to consumers, whereas doors with moderate levels of character were preferred less often than doors made from clear wood. These findings suggested a 'U-shaped' preference structure, whereby moderate levels of character-marking were the least preferred.

Wood species also can play a role in perceptions of wood products. Scholz and Decker (2007) found significant species effects when consumers evaluated attributes of solid wood furniture (dining tables). This study found that wood species not only influenced the material appearance, but also attributes like style and design. Bumgardner and Bowe (2002) suggested that species perception can be an important part of the total product concept for secondary wood products, and found that consumers maintained perceptual images of species even when they could not accurately identify these species. Bumgardner *et al.* (2007) found that species use could affect preferences for wood products at higher price-points.

Research objectives

As discussed above, the species used and the type and degree of wood features present in wood products can be

expected to elicit dissimilar perceptions among different groups through the value chain. The following objectives therefore were developed to assess perceptions of edge-glued panels made from Alaskan hardwoods:

- (i) to assess the overall interest in edge-glued panels among two groups: residential consumers and wood products manufacturers
- (ii) to evaluate panels constructed from two different species: paper birch and red alder
- (iii) to evaluate birch panels constructed primarily from wood exhibiting two different character features: knots and natural stain
- (iv) to evaluate birch and red alder panels at three different character mark frequency levels: light, moderate, and high.

Methods

Data collection

A survey of attendees was conducted at the TSI Woodworking Expo (Tacoma, Washington, November 2008) and at the Fairbanks Home Show (Fairbanks, Alaska, March 2009). At these events, people were asked to look at 11 edge-glued panel samples presented at a booth. In part I, respondents evaluated all 11 panels on a five-point scale (poor to excellent), based on three attributes: character marks, grain consistency and overall colour. In part II, respondents rated their preferences for two different groups of panels – red alder versus birch, and birch knots versus birch stain. Respondents also selected their three overall favourite panels. In part III, respondents provided either demographic data or company data. All data were collected in cooperation with the University of Alaska-Fairbanks wood products program. Respondents were offered a small forest products incentive (key chain or similar prize) for participation. Two different populations were sampled, using the same survey instrument. Our sample groups included:

- (i) wood products producers at a Woodworking Expo in Tacoma, WA ($n=129$)
- (ii) residential consumers at a Home Show in Fairbanks, AK ($n=475$).

In the residential consumer sample, 55% were male and 48% were at least 51 years of age (a plurality of 33% were 51 to 60 years of age). Over 56% had annual household income of at least \$75 000, with a plurality (30%) having household income of \$75 000 to \$100 000. In the wood products producer sample, most (89%) were male, and 43% were at least 51 years of age (a plurality of 31% were 51 to 60 years of age). Most represented small firms, as 42% had annual sales of less than \$250 000 (60% were \$1 million or less), and 71% had 10 or fewer employees (a plurality of 36% had two to five employees).

Panel construction

All panels were constructed to a size of 12 × 18 inches (30.5 × 45.7 cm), with each component being about 1–2 inches (2.5–5.1 cm) in width (Figs. 1–5). All lumber was kiln-dried and planed, followed by application of a clear coat finish. No other stains or finishes were applied so that the original colour and texture of the panels could be preserved.

For red alder, one panel was constructed using clear wood, and three panels were constructed using varying levels of knots (Table 1). Red alder lumber was selected



1 Red alder edge-glued panel (clear wood construction); dimensions of this photo frame are approximately 12 × 18 inches (30.5 × 45.7 cm)



4 Paper birch edge-glued panel (high level of knots); dimensions of this photo frame are approximately 12 × 18 inches (30.5 × 45.7 cm)



2 Red alder edge-glued panel (high level of character-marked wood); dimensions of this photo frame are approximately 12 × 18 inches (30.5 × 45.7 cm)

from material generated during a lumber recovery study near Ketchikan, Alaska (Brackley *et al.* 2009). For birch, one panel was constructed featuring clear wood, three panels featured varying levels of knots, and three panels featured varying levels of natural stain (Table 1). Birch lumber was selected from the retail inventory of a lumber store in Fairbanks, Alaska (and had been sawn locally). Therefore, four red alder panels and seven birch panels were constructed for a total of 11 panels.

Results

Residential consumers

Birch panels

Birch with natural stain (panel 11) was preferred by a wide margin among residential consumers, being selected 47.5% of the time (Table 2). This panel was also the highest rated panel on all three attributes evaluated (character marks, grain consistency and overall colour), with well over 80% rating each attribute as



3 Paper birch edge-glued panel (clear wood construction); dimensions of this photo frame are approximately 12 × 18 inches (30.5 × 45.7 cm)



5 Paper birch edge-glued panel (high level of natural stain); dimensions of this photo frame are approximately 12 × 18 inches (30.5 × 45.7 cm)

Table 1 Edge-glued panel descriptions

Panel number	Species	Character feature	
		Type	Level
1	Red alder	None (clear)	...
2	Red alder	Knots	Low
3	Red alder	Knots	Moderate
4	Red alder	Knots	High
5	Birch	None (clear)	...
6	Birch	Knots	Low
7	Birch	Knots	Moderate
8	Birch	Knots	High
9	Birch	Natural stain	Low
10	Birch	Natural stain	Moderate
11	Birch	Natural stain	High

good or excellent (Table 3). Panel 11 also showed strong results for the second favourite panel, being selected 16.5% of the time. This strong preference for a single panel was somewhat surprising considering that respondents could view all 11 panels in one setting, selecting any one of these as their favourite. By a wide margin, residential consumers preferred the birch panel group featuring natural stain (panels 9–11) to birch panels featuring knots (panels 6–8). Here, more than 86% of respondents favoured natural stain (Table 4). As shown in Table 4, residential consumers were not statistically different from producers in their strong preference for stained birch over knotty birch ($p=0.27$).

Red alder panels

Red alder panel 3 (moderate level of knots) was the least likely to have been selected as the favourite or second favourite panel of any red alder panel (Table 2). Residential consumers rated red alder panel 1 (clear wood) highly for colour and for grain (Table 3), and it was the most preferred alder panel (Table 2). Overall, it appeared that residential consumers preferred red alder panels that were either clear or with high levels of character (but not intermediate levels of character).

Red alder versus birch panels

Residential consumers preferred birch panels to red alder by almost a 2:1 margin (Table 4), and were statistically different from producers in their preference for birch ($p=0.04$). This result included a broad range of

character-mark features for each species group. Perhaps a common denominator when comparing red alder to birch panels was that the underlying colour (exclusive of character marks) was somewhat brighter for birch. Another potentially important distinction was that some birch panels (e.g. those with natural stain) had entire regions of character (Fig. 5), whereas red alder panels featured more discrete, localised regions of character (Fig. 2). Although these aspects were not measured quantitatively, they could have influenced residential consumer perceptions.

The red alder panels with knots (panels 2–4) generally received slightly higher attribute ratings when compared to the birch panels having knots (panels 6–8). However, the red alder panels with knots (panels 2–4) were somewhat less popular (Table 2) and lower rated for attributes (Table 3) versus birch panels having natural stain (panels 9–11).

Character-mark interest

Residential consumers exhibited a strong general interest in character-marked wood products when asked to rate their interest on a five-point scale (Table 5). More than 63% of respondents rated their interest as either 'high' or 'very high' (versus only 7% of respondents having 'low' or 'very low' interest). Residential consumers were statistically different from producers in this regard ($p<0.01$). Also for residential consumers, character marks were most highly rated for birch panels having natural stain versus any of the other panel groups. Here, character marks were rated as either good or excellent at least 70% of the time (panel 9), and as high as 86% of the time (panel 11) (Table 3).

Past use of hardwood species

Residential consumers indicated a high level of past use of birch, but not of red alder in household use (Table 6). This could have been influenced by the fact that the survey took place in Fairbanks, Alaska, where birch forests are common and birch lumber is sold in several retail centres (but not the case for red alder). In addition, red alder often is stained as a substitute for higher-valued species such as cherry (*Prunus serotina* Ehrh.). Past studies have shown that less than 5% of consumers in the Pacific Northwest could correctly identify red alder wood (Bumgardner et al. 2007). Thus, if products

Table 2 Edge-glued panel descriptions and overall preferences; residential consumers versus wood products producers

Panel	Species	Favourite panel		Second favourite panel	
		Residential consumer	Wood products producers	Residential consumer	Wood products producers
		Percentage of times chosen		Percentage of times chosen	
1	Red alder	10.8	10.2	8.2	15.4
2	Red alder	4.2	1.7	7.5	4.3
3	Red alder	1.8	4.2	4.4	8.6
4	Red alder	6.8	13.6	8.8	10.3
5	Birch	5.3	14.4	7.5	12.0
6	Birch	0.9	2.5	0.9	1.7
7	Birch	1.8	1.7	3.3	6.0
8	Birch	0.7	1.7	5.5	6.0
9	Birch	7.7	8.5	11.0	6.0
10	Birch	12.7	2.5	26.4	13.7
11	Birch	47.5	39.0	16.5	16.2
Total		100.2*	100.0	100.0	100.2

*Some totals are not 100.0 due to rounding.

Table 3 Percentage of time that red alder and paper birch edge-glued panels were rated good or excellent by residential consumers and wood products producers

Panel	Residential consumers			Wood products producers		
	Character marks	Grain	Colour	Character marks	Grain	Colour
	Percentage of time rated good or excellent*,†			Percentage of time rated good or excellent*,†		
1	47.3	71.7	70.4	62.2	65.4	78.9
2	58.1	53.6	56.8	44.9	29.1	39.2
3	56.6	59.3	68.1	53.5	48.4	58.1
4	57.4	58.9	68.3	55.9	55.2	65.8
5	40.0	61.6	52.5	54.4	78.7	71.4
6	43.8	46.9	42.5	38.3	35.4	28.6
7	52.5	56.7	60.3	57.8	61.1	57.3
8	49.2	48.9	58.1	45.2	44.8	37.1
9	70.1	75.9	74.6	60.8	59.7	66.4
10	78.3	74.9	78.8	59.2	50.0	53.2
11	86.5	84.6	87.3	79.4	75.2	76.6

*Based on five-point scale including: poor, fair, neutral, good and excellent.

†The 90% confidence interval is approximately 3.9% (+/-) for residential consumers and approximately 7.3 (+/-) for producers.

are not specifically marketed as being made of red alder, consumers might be unaware of its use. It also was noteworthy that residential consumers were statistically less likely than producers to have indicated past use of red alder ($p < 0.01$), but not birch ($p = 0.23$).

Wood products producers

Birch panels

Among wood products producers, birch with high levels of natural stain (panel 11) was preferred by a wide margin, being selected 39% of the time (Table 2). This panel was among the highest rated panels for all three attributes evaluated (character marks, grain consistency and overall colour), with over 75% of all respondents rated panel 11 as good or excellent on these attributes (Table 3). Clear birch wood (panel 5) also was rated highly for overall colour and grain consistency. Panels from the birch stain group were considerably more popular than those from the birch knot group. Similar to residential consumers, 82% of respondents favoured birch natural stain over birch panels with knots (Table 4).

Red alder panels

Highly character-marked red alder (panel 4) was the most popular red alder panel among wood products producers, being chosen as overall favourite nearly 14% of the time (Table 2). The clear red alder panel (panel 1)

was highly rated for colour (Table 3), and was selected as the favourite about 10% of the time. The red alder panels having intermediate levels of character (panels 2 and 3) were rarely selected as the favourite.

Red alder versus birch panels

Overall, the red alder panels compared favourably to birch panels for character mark preference scores (Table 3), except for birch panel 11, which rated somewhat higher. In general, birch panels were more popular than red alder among wood products producers (Table 4), with birch panels being preferred about 57% of the time, but statistically less than residential consumer preference for birch.

Character-mark interest

Wood products producers indicated statistically less interest in character-marked wood than did residential consumers, with a plurality (38%) of respondents indicating only a moderate general interest in using character-marked wood in their products (Table 5). Although 45% of respondents indicated a high or very high interest in character-marked wood, this was less than the 63% of residential consumers indicating high or very high interest. Previous studies have shown that retailers are somewhat risk-averse to using character-marked wood in their products (Bumgardner *et al.* 2001) and less likely than consumers to associate character-

Table 4 Overall preferences for red alder versus paper birch edge-glued panels; residential consumers and wood products manufacturers

	Residential consumers		Wood products producers	
	Count	Percentage of total	Count	Percentage of total
Species*				
Red alder	131	32.6	48	43.2
Birch	271	67.4	63	56.8
Total	402	100	111	100
Birch character-marks†				
Birch knots	56	13.7	18	18.0
Birch natural stain	354	86.3	82	82.0
Total	410	100	100	100

*Chi-square statistic for this 2×2 table = 4.35; $p = 0.04$.

†Chi-square statistic for this 2×2 table = 1.22; $p = 0.27$.

Table 5 General interest in character-marked wood products; home owners and wood products manufacturers*

	Residential consumers		Wood products producers	
	Count	Percentage of total	Count	Percentage of total
Very high	87	21.0	15	13.8
High	176	42.4	34	31.2
Moderate	123	29.6	42	38.5
Low	27	6.5	13	11.9
Very low	2	0.5	5	4.6
Total	415	100.0	109	100.0

*Chi-square statistic for this 2 × 5 table = 21.4; $p < 0.01$

marks with willingness-to-pay for furniture products (Brinberg et al. 2007).

Past use of hardwood species

Wood products producers indicated a relatively high past usage of red alder, with over 61% of respondents indicating some past use of this species (Table 6). Birch was also widely used among wood products producers, with almost 74% of respondents indicating some past use. The difference between residential consumers' reported use of red alder and reported use by producers was notable; assuming the producers were not exporting products, these percentages should in reality be much closer, such as was the case for birch.

Discussion and conclusions

This study found very strong preferences for birch panels having high levels of natural stain, and to a lesser degree, birch panels having moderate levels of stain. This trend was especially apparent for residential consumer. For both groups, birch panels containing stain were greatly preferred to birch panels containing knots, suggesting this type of character-mark generally has greater appeal than knots. However, there were several differences in perceptions between residential consumers and wood products producers. Residential consumers favoured birch panels (versus red alder panels) to a somewhat greater extent than did wood product producers. Furthermore, a majority of producers reported using red alder in the past, whereas very few consumers reported past use of red alder. This illustrates the paradox associated with alder – it has become a widely utilised industrial species but is still relatively unknown to consumers.

Some respondents mentioned anecdotally that the overall appearance of the birch stained panels was similar to a hickory species (i.e. a distinctive striped look). This could suggest advantages for products to imitate more popular or more expensive products. It is important to note that the highly popular birch panels (with natural stain) also contained some knots, and therefore the

overall appeal of this panel could be in part due to the mixture of character features present. The popularity of the birch stained panels seems consistent with Broman (2000) who found that preferences for knotty wood surfaces were connected with a physical blend of wood features, and that it was important to avoid a state of 'disharmony' for appearance of knotty surfaces. This could be particularly important for edge-glued panels if divergent texture or colour were present on adjacent laminates. In the present study, laminates were selected individually for each panel with an effort to minimise the variation in colour or overall features between laminates.

When considering red alder panels, clear wood was generally preferred by both residential consumers and wood products producers (Table 2). The colour of clear red alder also received high ratings. However, wood products producers also showed strong interest in red alder having high levels of character (i.e. knots). These results are in general agreement with past research (Donovan and Nicholls 2003) in which respondents favoured either high levels of character or clear wood (but less preference for intermediate levels of character). In the current study, the lowest attribute ratings for both species (Table 3) tended to occur for panels having moderate levels of character. This finding would suggest that manufacturers could benefit from lumber sorting strategies where clear wood and high character wood are separated from intermediate grades.

An anecdotal finding of this study (based on informal comments by participants while evaluating the panels) was that surface roughness associated with knots should be avoided. This was apparent in several of the birch panels features knots (panels 6 through 8), and also for the red alder panel having high levels of character (panel 4). Surface roughness, although not directly measured in our study, may be one reason for the relatively low attribute ratings for these panels. This hypothesis is in general agreement with Jonsson et al. (2008) who found that smoothness can be one of the preferred core categories of wood.

Table 6 Past use of red alder and paper birch; residential consumers and wood products manufacturers

	Red alder*				Paper birch†			
	Residential consumers		Wood products producers		Residential consumers		Wood products producers	
	Count	Percentage of total	Count	Percentage of total	Count	Percentage of total	Count	Percentage of total
Yes	48	11.8	68	61.3	281	67.7	81	73.6
No	360	88.2	43	38.7	134	32.3	29	26.4

*Chi-square statistic for this 2 × 2 table = 123.2; $p < 0.01$.

†Chi-square statistic for this 2 × 2 table = 1.4; $p = 0.23$.

Our study found that wood products producers could emphasise highly stained birch in their product mixes, and secondarily red alder having few or no defects. However, it is important to keep in mind that our study evaluated components and not finished products. Product design (in finished products) has been found to be an important contributor to perceptions of wood products (Brinberg et al. 2007, Wang et al. 2004) but it was not possible to include this in the current study. Product location (within a home) could also be an important factor influencing panel preferences. Another limitation of this study is that residential consumers were evaluated in one fairly small market in interior Alaska. Wood products producers were also evaluated at one location; however, this event was a regional woodworking expo, and therefore may have drawn attendees from throughout the Seattle-Tacoma area and beyond.

References

- Araman, P. 1983. Standard-size blanks for furniture and cabinets. NE-INF-45-83. US Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. Delaware, OH, USA. Page 6.
- Bigsby, H. R., Rai, C., and Ozanne, L. K. 2005. Determining consumer preferences for furniture timber. *J. Forest Prod. Bus. Res.* 2(2): 16.
- Bowyer, J. L., Kallio, E., Monson, C. R., and Nicholls, D. L. 1986. Standard blanks: a new alternative to hardwood lumber. *Forest Prod. J.* 36(2): 67–73.
- Brackley, A. M., Nicholls, D., and Hannan, M. 2009. An evaluation of the grades and value of red alder lumber in southeast Alaska. Gen. Tech. Rep. PNW-GTR-774. US Department of Agriculture, Forest Service, Pacific Northwest Research Station, Portland, OR, USA. Page 27.
- Brinberg, D., Bumgardner, M., and Daniloski, K. 2007. Understanding perception of wood household furniture: application of a policy capturing approach. *Forest Prod. J.* 57(7/8): 21–26.
- Broman, N. O. 1995. Visual impressions of features in Scots pine wood surfaces: a qualitative study. *Forest Prod. J.* 45(3): 61–66.
- Broman, N. O. 2000. Means to measure the aesthetic properties of wood. PhD thesis. Lulea University of Technology, Lulea, Sweden, p. 26.
- Broman, N. O. 2001. Aesthetic properties in knotty wood surfaces and their connection with people's preferences. *J. Wood Sci.* 47: 192–198.
- Bumgardner, M. S., and Bowe, S. A. 2002. Species selection in secondary wood products: implications for product design and promotion. *Wood Fiber Sci.* 34(3): 408–418.
- Bumgardner, M., Bush, R., and West, C. 2001. Knots as an incongruent product feature: a demonstration of the potential for character-marked hardwood furniture. *J. Inst. Wood Sci.* 15(6): 327–336.
- Bumgardner, M., Nicholls, D., and Donovan, G. 2007. Effects of species information and furniture price on consumer preferences for selected woods. *Wood Fiber Sci.* 39(1): 71–81.
- Bumgardner, M., Nicholls, D., and Barber, V. 2009. Character-marked furniture made from red alder harvested in southeast Alaska: product perspectives from consumers and retailers. *Can. J. For. Res.* 39(12): 2450–2459.
- Donovan, G., and Nicholls, D. L. 2003. Consumer preferences and willingness to pay for character-marked cabinets from Alaska birch. *Forest Prod. J.* 53(11/12): 27–32.
- Jonsson, O., Lindberg, S., Roos, A., Hugosson, M., and Lindström, M. 2008. Consumer perceptions and preferences on solid wood, wood-based panels, and composites: a repertory grid study. *J. Wood Fiber Sci.* 40(4): 663–678.
- Luostarinen, K., and Möttönen, V. 2009. Effect of felling season, storage and drying on colour of silver birch (*Betula pendula*) wood from four different growing sites. *Silva Fennica* 43(4): 699–709.
- Luostarinen, K., and Verkasalo, E. 2000. Birch as sawn timber and in mechanical further processing in Finland. A literature study. *Silva Fennica Monographs* 1.
- Scholz, S. W., and Decker, R. 2007. Measuring the impact of wood species on consumer preferences for wooden furniture by means of the Analytic Hierarchy Process. *Forest Prod. J.* 57(3): 23–28.
- Sevola, Y. (edited). 1998. Metsätalustollinen vuosikirja 1999. Jyväskylä: Finnish Statistical Yearbook of Forestry.
- Swearingen, K. A., Hansen, E. N., and Reeb, J. E. 1998. Customer preferences for Pacific Northwest hardwoods. *Forest Prod. J.* 48(2): 29–33.
- Verkasalo, E. 1997. Hieskoivun laatu vaneripuuna. [Quality of European white birch (*Betula pubescens* Ehrh.) for veneer and plywood]. Finnish Forest Research Institute, Finland. Research Paper 632.
- Wang, Q., Shi, G., and Chan-Halbrendt, C. 2004. Market potential for fine furniture manufactured from low-grade hardwood: evidence from a conjoint analysis in the northeastern United States. *Forest Prod. J.* 54(5): 19–25.