Impact of Paper Birch (*Betula papyrifera*) Tree Characteristics on Lumber Color, Grade Recovery, and Lumber Value

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Abstract

The aim of this research is to assess the impact of paper birch (*Betula papyrifera* Marsh.) tree characteristics on wood color variability, grade recovery, and lumber value. Current results are based on 2,284 paper birch boards coming from 168 trees harvested in two different stands in Québec, Canada. Results showed that tree diameter was the most important variable affecting board quality and value. Larger trees were associated with higher board quality and higher lumber value per tree. Lumber value per tree was influenced by tree vigor as well but not by tree age. The most vigorous trees produced higher board value with an average of USD 316.62 per m^3, middle vigor classes showed averages of USD 218.28 per m^3 and USD 251.84 per m^3, while the less vigorous trees had the lowest average with USD 165.94 per m^3. Board quality was only partly influenced by tree age and tree vigor. When selected for color, the majority of the board surface area fell under the *sap* category (50%), while 28 percent was classified as *regular* presenting simultaneously both colorations, and finally only 4 percent of the board area was classified as *red*. It was found that the most important variables affecting this board color distribution were tree vigor and tree diameter, whereas tree age also had a significant but lesser impact. In general, older, larger, and less vigorous trees tended to present higher proportions of boards classified in the *red* category. Finally, the results obtained in this study tend to support the practice of silvicultural treatments aiming to produce larger trees yielding higher value and quality boards.

Paper birch (*Betula papyrifera* Marsh.) is currently becoming an interesting alternative to the high-value species traditionally transformed by the sawmilling industry in Québec (Canada). It is frequently used in association with yellow birch (*Betula alleghaniensis* Britton) in several wood appearance product applications; its pale and homogeneous sapwood is suitable for many indoor uses. It tends to develop a darker brown-reddish discolored wood around the heart location that generates boards contrasting in coloration, a situation that is challenging for producing homogeneously colored wood products.

The brown-reddish discoloration found in paper birch wood is considered traumatic heartwood in the literature (Campbell and Davidson 1941; Shigo 1967, 1986; Siegle 1967; Shigo and Larson 1969; Shigo and Hillis 1973; Basham 1991; Allen 1996; Hallaksela and Niemisto 1998; Boulet 2005). In opposition to normal heartwood that is related to aging processes, traumatic heartwood, also called red heartwood or false heartwood, results from processes associated with tree injuries, tree internal defense, and the action of microorganisms. Its importance in paper birch resources and products has been assessed by a number of authors. Basham (1991), sampling 936 trees in a province wide survey in Ontario, Canada, found that discoloration represented 70 percent of the paper birch volume of defects. Giroud et al. (2008) reported that discolored wood corresponded to 13.3 percent of the tree merchantable

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volume; a proportion obtained measuring 18 paper birch trees. In a study in which 12 paper birch stems were dissected into more than 200 smaller stem sections, Belleville et al. (2008) found that 98 percent of those stem sections had some discolored wood. Campbell and Davidson (1941) reported that most paper birch trees older than 50 years presented some discoloration, and they qualified the discoloration as considerable in trees older than 70 years. Finally, Brière (1992) mentioned red heartwood as the most important defect in paper birch for appearance products, with small knots and bark inclusions being, respectively, the second and third in importance.

The link established between paper birch wood discolorations and tree defect prompts an analysis of the relationship between tree vigor and wood color as well as lumber recovery. In the province of Québec, tree selection has become the main silvicultural strategy to manage uneven-aged hardwood stands. Under this system, MSCR classification (Boulet 2005) is used to determine tree vigor and identify trees with high mortality probabilities based on external tree defects. Trees classified as M (*mourir*) are *dying stock* and those as S (*survie*) are *surviving stock* correspond to the less vigorous trees. Trees classified as C (*conserver*) are *growing stock* and those as R (*réserve*) are *premium growing stock*; these are the most vigorous trees. Looking at trees' morphological, mechanical, or pathological characteristics, the most severe defects are identified to determine tree vigor and predict its life expectancy. Tree defects are divided into eight levels of severity. From the most severe to the least we find (1) fungi, (2) cankers, (3) tree defects and bark wounds, (4) abnormalities of the tree butt and roots, (5) cracks and bark fissures, (6) insects and birds damages, (7) crown abnormalities, and (8) natural branch shedding (Nolet et al. 2007). The vigor category is assigned according to the presence of these defects in the tree.

The harvesting priorities are subsequently determined upon these MSCR classes, M being the highest harvest priority. The impact of this new classification system (MSCR) on board recovery was assessed (Duchesne 2006), and it was found that it takes twice the number of dying trees (M) to produce 1,000 board feet (MBF) compared with the most vigorous trees (R). The total average revenue per net cubic meter (m^3) of stem was CAD 90.99 per m^3 for the M trees and CAD 163.08 per m^3 for the R trees, when boards were unselected for color. When selected for color, these values reached respectively CAD 95.50 per m^3 and CAD 194.90 per m^3. Consequently, following these results, sawmill revenues are expected to decrease in the future due to their obligation to harvest less vigorous trees in priority, and this will continue until hardwood stands recover some of their vitality.

Concerning board quality, as the majority of the hardwood lumber traded in North America that is remanufactured into other products, paper birch lumber is commonly classified according to the National Hardwood Lumber Association (NHLA 2007) rules. The most common grades for birch are FAS, Fas one face (F1F), Select, No. 1 Common, No. 2A Common, No. 3A Common, and No. 3B Common; what is not graded is used for pallet. The minimal requirements determining these grades are linked to the final end-use attributes. The higher grades, FAS, F1F, and Selects, provide long clear pieces suitable for moulding, joinery, and furniture pieces that require long and wide cuttings. Lower grades such as No. 1 Common and No. 2A Common contain smaller cuttings appropriate for furniture components as well as flooring and the cabinet industry. The lowest grades are for industrial use. For all grades, the minimal requirements are determined on the poorest face of the boards except for F1F and Select for which the better face must meet FAS requirements and the poorest face must meet No. 1 Common requirements.

Under these grading rules birch is normally unselected for color, meaning that wood color is not considered in the quality assessment. However, homogeneously colored boards can be set aside for a premium price under the red and sap categories for most of the NHLA classes. For a board to get the red birch assignation, each of the cuttings must have one clear heartwood face of uniform dark color. Similarly, for sap birch, each of the cutting must have one clear sapwood face of white color. These two specific color-based classes are sold at a higher price on the market (Table 1).

Previous studies assessed the potential sources of variation of paper birch wood color at the tree level (Drouin et al. 2009) and at the log level (Drouin et al. 2010). It was found that tree diameter and tree vigor were the two most important variables affecting the proportion of discoloration in boards, while tree age, log height class, and log quality did not significantly affect this proportion. Larger and less vigorous trees showed boards with higher amounts of discolored wood.

The present study aimed to draw a portrait of the value and quality of the paper birch wood products obtained from 168 trees harvested in Québec for two previous studies. The objective of the study was to establish the relationship between birch tree characteristics and lumber value per tree as well as grade recovery, including color selection.

Materials and Methods

Material collection and preparation

Paper birch stems were collected in two stands located north of the Laurentian region in the province of Québec, Canada (47°N, 74°W). In the winter of 2005, 100 paper birch stems were selected in an overmature mixed stand. Two years later 68 stems were selected in a second stand of younger trees located less than 1 km away from the first one, on the same ecological type (MJ22: yellow birch-fir forest on modal site; Gosselin 2002). Trees were selected upon the MSCR tree classification established by the Québec Ministry of Natural Resources and Wildlife (Boulet 2005) in order to get a fair distribution in each class. Thirty-two

Table 1.—Market prices for the principal grades of birch lumber, Spring 2009.[a]

NHLA category	Price (USD per MBF)[b] Regular	Red	Sap
FAS	1,055	1,360	1,335
Select	1,035	1,340	1,315
No. 1C	650	955	930
No. 2A	415	720	695
No. 3A	285	590	565
No. 3B (pallet)	225	—	—

[a] Source: Hardwood Market Report, March 14, 2009.
[b] FOB mills, 4/4, green, rough, random widths and lengths, for single bundles.

percent of the trees were classified as M (dying), 26 percent as S (surviving), 22 percent as C (growing), and 20 percent as R (premium).

Trees of the first stand were harvested at the end of March 2005, left in the forest with their branches intact until June 2005. Trees of the second stand were harvested and delimbed on site in October 2007. These full length trees were afterward cut into logs following optimized slashing based on Petro and Calvert (1976) rules for log quality. Including both stands, a total of 447 logs were produced, from which 215 were sawlogs and 232 were pulpwood. These logs originated from 68 of the 100 previously selected trees in the first stand and from 54 of the 68 selected trees in the second stand, while the remaining trees yielded only pulpwood logs (Table 2).

For those 122 trees that produced sawlogs, the diameter at breast height (DBH) ranged from 24 to 66 cm, with an average of 33 cm over both stands. Tree age ranged from 46 to 154 years, with a mean of 101 years. While most of the trees coming from the first stand were older than 100 years with an average of 122 years, trees of the second stand were younger than 100 years with an average of 74 years.

Log quality was assessed and measured under the provincial grading system of The Québec Ministry of Natural Resources and Wildlife (MRNFQ 2007) for which logs are classified either as A for veneer logs, B and C for sawlogs, D for pulp wood, or E for short logs, and under a similar system by Petro and Calvert (1976) for which sawlogs are classified as F1, F2, F3, or F4 (short logs).

These logs were sawn into boards in hardwood sawmills, using a sawing around pattern, in June 2005 for the first stand and in October 2007 for the second stand. In the first sawmill the central blocks were not transformed directly. They were resawn into boards on a ‘‘Wood Mizer’’ portable sawmill shortly afterward. From those operations a total of 2,284 usable paper birch boards were produced.

The produced boards had dimensions that ranged from 1.22 to 3.66 m (4 to 12 ft) in length and from 7.6 to 33.0 cm (3 to 13 in.) in width while their thickness was of 4/4 (25.4 mm or 1 in.). These boards were graded under the NHLA grading rules (NHLA 2007) prior to drying. In addition, selection for color was done, with the red and sap categories being assigned to homogeneously colored boards.

All boards were dried by conventional kiln drying in the month following the sawing for both stands, according to a mild schedule that reached a maximum temperature of 140°F (Normand 2004). They were planed on both faces using a moulder (Weinig Unimat 23 EL) to get a fresh and clean surface before scanning to study wood color.

Colorimetric analysis on paper birch boards

The colorimetric analysis was performed on board images acquired by an industrial scanner developed by the CRIQ (Centre de recherche industrielle du Québec) for appearance wood applications, the BorealScan (Caron 2005). For each board two digital images were recorded (i.e., one on each face), and defects were automatically identified by the scanner. Image processing software developed for the scanner, CRIQTraitement, was used to view images, to process them, and to assess the colorimetric information. The software allowed for the segmentation of the board images into two different zones representing white wood and discolored wood, based on the pixel color intensity.

Table 2.—Summary of the experimental design.

Material attributes	Stand: First	Stand: Second
No. of trees harvested	100	68
No. of trees that produced sawlogs	68	54
No. of sawlogs	130	85
No. of pulp logs	131	101

Lumber value

Board prices were determined using the Hardwood Market report price list of March 14, 2009 (Hardwood Market Report 2009; Table 1), which presents current market prices for each NHLA grade. The prices, in US dollars per 1,000 board feet, were assigned from birch in the Northern Hardwood table, and they are FOB mill prices for boards of random widths and lengths, 4/4, green, and rough. Prices for the No. 3B Common category (pallets) were obtained from this same report under the pallet lumber for the 4/4 random widths. Prices for color selection were used, meaning that additional values of USD 305 per MBF and USD 280 per MBF were added for boards classified as red and sap, respectively.

Lumber value was determined on a tree basis. The lumber value per tree is the sum of the total value of all boards of a tree over the volume of these boards and is expressed in US dollars per cubic meter (USD per m^3).

Statistical analysis

Results were analyzed using the SAS software version 9.1 for Windows (SAS Institute Inc. 2003). In the case of the lumber value per tree, a multiple regression was used to simultaneously test and model the effect of tree age, diameter, and vigor on this variable. A mixed model procedure was used to take into consideration the random effects associated with the hierarchical nature of the data—i.e., the associations between trees belonging to the same stands. In the case of the NHLA and red/regular/sap distributions, logistic regressions were used due to the categorical nature of these dependant variables. Again, the effect of tree age, diameter, and vigor were assessed. Random effects were also added in these models, to consider the associations between the boards belonging to the same logs, trees, and stands. The fact that these random effects were included in the model did not allow using polynomial (or polychotomous) logistic regressions. Therefore, many binary (or individual) logistic regressions were used to compare separately each level of the variation of the dependant variables. According to Begg and Gray (1984), using numerous binary logistic regressions does not take away too much efficiency from the model and results are comparable to a polynomial logistic regression including the same comparisons. The Bonferroni correction was applied on the probability values when assessing the tree vigor effect because of the multiple comparisons that were done.

Results

Grade recovery

NHLA grading result as a percentage of the 2,284 boards evaluated are presented in Table 3 along with the percentage on a surface area basis, with no consideration for color. The surface area is expressed in terms of surface measure (SM),

Table 3.—Lumber grade distribution based on the NHLA classification system.

NHLA grade	% of total no. of boards	% of board SM[a]
FAS	0	0
F1F	0	0
Select	14.8	19
No. 1 Common	17.6	21
No. 2A Common	21.7	20
No. 3A Common	24.8	22
No. 3B Common (pallet)	21.2	18

[a] SM = surface measure.

a unit that corresponds to the surface area of a board in square feet. SM is obtained by multiplying the width of the boards (in inches) by the length of the board (in feet) and by dividing by 12. The value is rounded to the closest whole number.

When the number of boards is considered, the higher proportions are found in the lower NHLA grades while the grade distribution is more evenly distributed on a board surface basis, without considering that no FAS or F1F board was found in the sample. The No. 3A Common category obtained the highest percentage of boards and of SM. It was followed by the No. 2A Common, No. 3B Common, No. 1A Common, and Select categories, in terms of number of boards, and by the No. 1 Common, No. 2A Common, Select, and No. 3B Common categories in terms of SM.

Effects of the tree characteristics on the NHLA grade distribution were analyzed (Table 4). Results show that tree diameter is the most important variable affecting the NHLA grade distribution in this study. In this analysis, the Bonferroni correction lowered the significance level at 0.005 due to the 10 comparisons that were done. In paired comparison between NHLA grades, it was found that, as tree diameter increased, the chances of boards being classified in the superior quality also increased. These probabilities obtained a statistical significance for the following pairs of classes:

- Select–No. 2A Common
- Select–No. 3A Common
- Select–pallet
- No. 1A Common–No. 2A Common
- No. 1A Common–No. 3A Common

Table 4.—Statistical results of the analysis of the effect of tree characteristics on lumber recovery.

	Tree characteristics[a]		
Regression pairs	Tree age	Tree diameter	Tree vigor (MSCR)
1 Com–Select	0.0715	0.9269	0.2685
2 Com–Select	0.0204	0.0050*	0.2512
3 Com–Select	0.311	0.0016*	0.1046
Pallet–Select	0.0220	0.0020*	0.0492
1 Com–2 Com	0.6129	<0.0001*	0.2101
1 Com–3 Com	0.3366	<0.0001*	0.4392
1 Com–pallet	0.3507	<0.0001*	0.2730
2 Com–3 Com	0.1094	0.3296	0.0315
2 Com–pallet	0.1379	0.3977	0.1456
3 Com–pallet	0.5610	0.7803	0.3993

[a] Asterisk indicates significance. Due to the application of the Bonferroni correction, the significance level applied to the individual multiple comparison tests was 0.005 (α/n or 0.05/10).

- No. 1A Common–pallet

For each of these pairs, the superior NHLA quality was favored when the tree diameter increased. The effect of tree age on the NHLA distribution was similar. Older trees produced higher chances to get boards classified in the better NHLA grades. Nevertheless, the tree age influence was smaller than the tree diameter with significant probabilities associated with the following comparisons:

- Select–No. 2A Common
- Select–No. 3A Common and
- Select–pallet

Again, the chances of getting the Select category were always greater than getting the No. 2A Common, No. 3A Common, and pallet categories when trees were older.

Tree vigor (MSCR) had only a limited impact on board quality; it significantly impacted only the No. 2A Common–No. 3A Common comparison. When trees classified as S and C were compared, trees classified as S had higher chances of producing boards classified as No. 2A Common than No. 3A Common. In other words for these two tree vigor classes, the less vigorous trees presented higher probabilities of producing more No. 2A Common boards than No. 3A Common boards.

Selection for color

The previous results are for unselected boards, meaning wood color was not considered in the classification. When selected for color, the next distribution of SM proportions was observed: 50 percent of the boards' surface area was classified in the sap category, i.e., the cutting units in these board were uniformly covered by the sapwood pale color; the SM of 28 percent of the boards was classified in the regular category, in which board surface presents a mix of sapwood and discolored wood; while only 4 percent of the boards were classified in the red category for SM, in which boards present cutting units covered by the red heartwood. Pallet quality boards (No. 3B Common) are never selected for color since their application does not require appearance quality standards; they represented 18 percent of the total.

Figure 1 shows the distribution of this color classification among the NHLA grades. It can be observed that the surface area classified as sap always represents the highest proportion of SM for each NHLA categories and it is fairly equally distributed among these categories. Board surface area classified as red represents by far the smallest

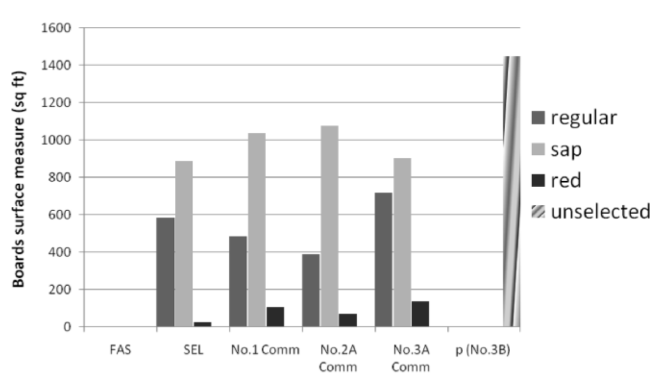

Figure 1.—Distribution of board surface areas among the different color classifications of the NHLA grades.

proportion of the total SM and it is found mostly in the lower NHLA categories. The highest proportion of SM classified as regular is found in the No. 3A Common category, followed by the Select, No. 1 Common, and No. 2A Common categories.

Logistic regressions were performed in order to determine which tree characteristics principally influenced this board color classification. Results show that tree age, diameter, and vigor all had some significant impact on the proportion of boards in these color classes, but not for every comparison (Table 5). Owing to the numerous comparisons realized, the Bonferroni correction was used to adjust probability values, the significance level was lowered to 0.017.

When tree age increased, the probability of obtaining sap boards instead of regular boards decreased (Fig. 2). In other words, older trees tended to produce fewer boards completely included in white clear wood. This trend can be observed in Figure 2, which presents the descriptive statistics of the effect of tree age on the board color classification and shows that the proportions of red and regular boards increase as trees get older while at the same time the proportion of sap board is decreasing.

Tree diameter affected board color in the same way (Fig. 3). The probability of obtaining red versus regular boards as well as red versus sap boards was found to be statistically significant. In both cases as tree diameter increased, the red category was favored meaning that larger trees produce more discolored wood. These trends are illustrated in Figure 3 where the proportion of red classified boards increases as the tree diameter increases.

Finally, these results demonstrate a significant influence of the tree vigor on the board color classification in which the highest proportions of sap boards were found in the most vigorous trees (Fig. 4). Tree vigor effect was significant on two comparisons (red vs. sap and regular vs. sap). In both cases, as the tree vigor increased, the probability of getting sap boards over red and regular boards also increased. Significant differences were found between the M and the R tree vigor classes, i.e., the least and the most vigorous trees, for both comparisons. Trees classified as M produced more of regular and red boards over sap boards compared with trees classified as R (Fig. 4). In other words, the less vigorous trees produced fewer clear white boards.

Lumber value

Boards were allocated prices according to the Hardwood Market Report price list (Table 1; Hardwood Market Report 2009). When the total price obtained for all boards considered in the present study was compared for boards selected for color and for unselected boards, it was found

Table 5.—Statistical results of the analysis of the effect of tree characteristics on board color classification.

	Tree characteristics[a]		
Regression pairs	Tree age	Tree diameter	Tree vigor (MSCR)
Red–regular	0.3025	<0.0001*	0.0224
Red–sap	0.9734	<0.0001*	0.0072*
Regular–sap	0.0004*	0.2138	0.0114*

[a] Asterisk indicates significance. Due to the application of the Bonferroni correction the significance level applied to the individual multiple comparison tests was 0.017 (α/n or 0.05/3).

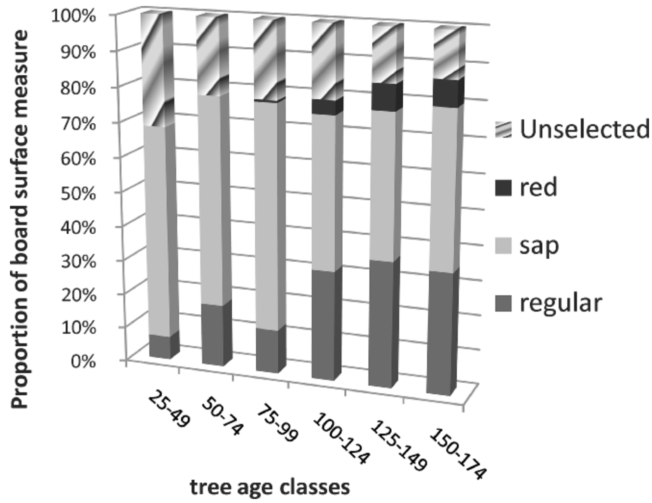

Figure 2.—Effect of tree age on board color classification under the NHLA rules.

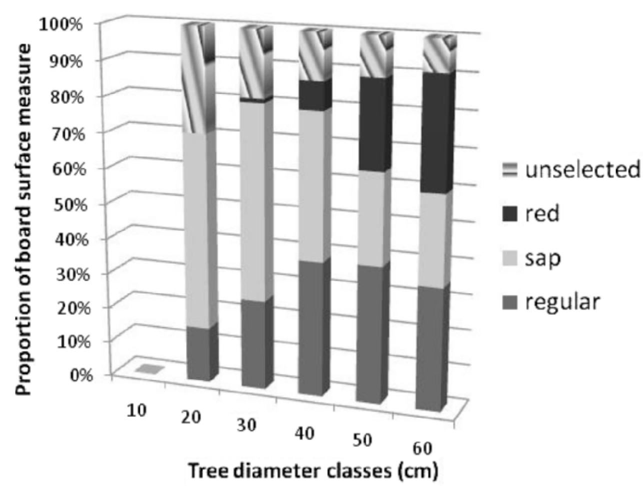

Figure 3.—Effect of tree diameter on board color classification under the NHLA rules.

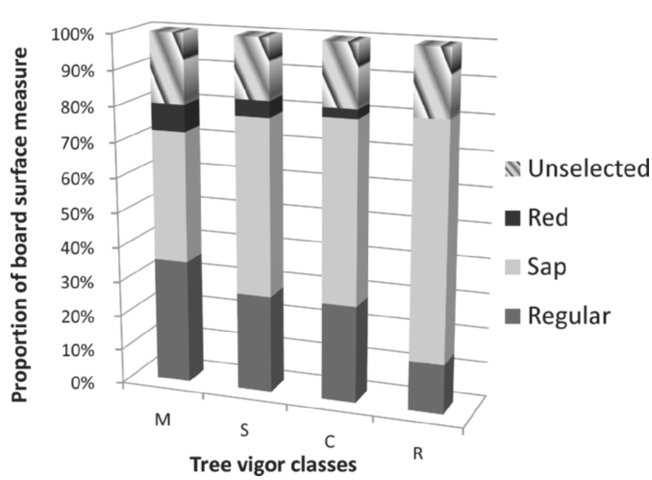

Figure 4.—Effect of tree vigor on board color classification under the NHLA rules.

that selecting for color yielded a price premium of 18 percent.

Lumber value per tree was calculated. When all of the 122 trees of the study are considered, a mean value of USD 230.76 per m^3 was obtained. The range of values was fairly large, from a minimum of USD 99.38 per m^3 to a maximum of USD 412.62 per m^3, with a standard deviation of USD 58.49 per m^3.

The effect of tree characteristics on the lumber value per tree was assessed (Table 6; Fig. 5). The statistical analysis showed that tree diameter and tree vigor had a significant effect on this variable, but not tree age ($P = 0.3122$). Larger diameter trees produced boards with a higher value per cubic meter.

Regarding tree vigor, the most vigorous trees (R class) had an average intrinsic value of USD 316.62 per m^3 when all boards were considered. Middle classes S and C showed averages of USD 218.28 per m^3 and USD 251.84 per m^3, respectively. The less vigorous trees (M class) had the lowest average with USD 165.94 per m^3 (Fig. 6). A significant difference in the lumber value per tree was found for classes M and S. Moreover, when this lumber value per tree variable was averaged by stand, a mean value of USD 241.17 per m^3 was obtained for the first stand and USD 216.55 per m^3 for the second stand. The random effect taking into account the variability associated to the stand was considered in the mixed model but was not found to be significant.

Discussion

The grade recovery results showed that the paper birches analyzed yielded a high proportion of low-grade lumber according to the NHLA rules, with 60.3 percent of the total

Table 6.—Statistical results of the analysis of the effect of tree characteristics on lumber value (USD per m^3).

	df			
Tree characteristic	Numerator	Denominator	F value	$P > F$[a]
Tree age	1	115	1.03	0.3122
Tree diameter	1	115	17.13	<0.0001*
Tree vigor (MSCR)	3	115	3.75	0.0130*

[a] Asterisk indicates significance.

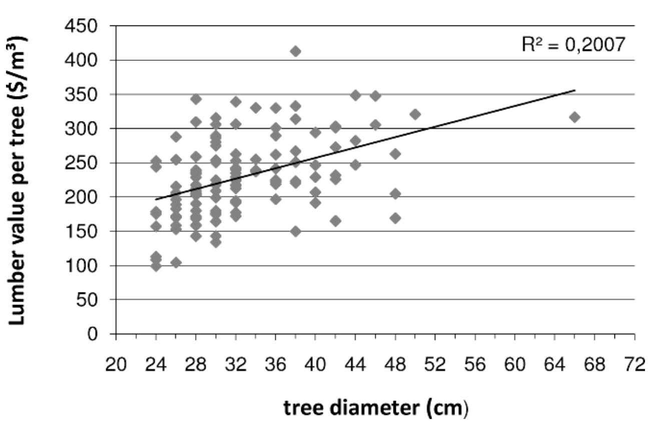

Figure 5.—Lumber value per tree in relation to tree diameter (DBH).

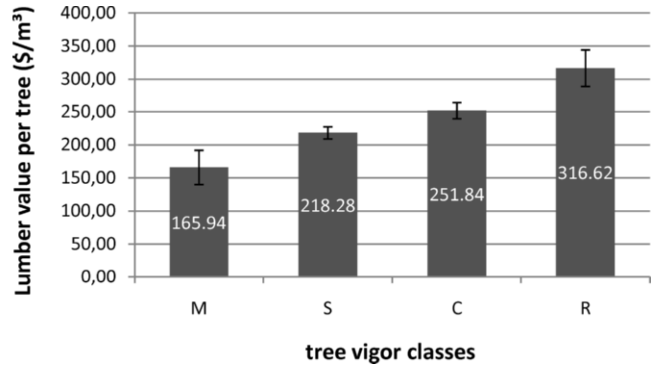

Figure 6.—Lumber value per tree in relation to tree vigor (MSCR).

board surface area graded as No. 2A Common and lower quality classes.

Concerning the effects of tree characteristics on grade recovery, tree diameter, and to a lower extent, tree age and tree vigor were found to have a significant effect. The fact that larger diameter trees produce higher quality boards can be explained by NHLA grading rule specifications for which the amount of cutting units per board is the main criterion for board classification. These rules are set because higher quality grades are intended for a final product requiring long and wide pieces. Hence, larger trees produce larger boards in which it is easier to find the minimal cutting unit required for high quality standards. Tree age had a similar effect as tree diameter on grade recovery, but not as important. Older trees showed higher probabilities for producing higher quality boards. These results suggest that silvicultural treatments enhancing tree growth, such as partial cutting, would favor higher quality boards and therefore higher margins, mainly due to board size. These treatments should, however, be realized with caution in order to limit stem wound or limb breakage inflictions, these wounds being known to induce discolored wood in paper birch stems. Waiting for a longer harvesting rotation is another way to obtain larger and older trees that will produce higher quality boards. On the other hand, in the first part of this study, shorter rotations were suggested to limit the presence of red heartwood in paper birch boards (Drouin et al. 2009). Therefore a trade-off has to be made when taking silvicultural decisions to decide whether higher quality or paler wood is the most important characteristic.

Tree vigor was expected to have a stronger influence on board quality, but it significantly affected only one individual logistic regression. Furthermore, the result of that comparison was counterintuitive, i.e., the less vigorous trees had higher probabilities of producing boards of better quality, i.e., No. 2A Common boards over No. 3A Common boards. The limited impact of tree vigor on board quality suggests that tree defects that were used to evaluate tree vitality and predict their death were not defects that had an important influence on the wood quality. The most important impact of these tree defects seems to be on the wood color. In a previous study (Drouin et al. 2009), it was found that the less vigorous trees, i.e., presenting more external defects, produced boards with higher proportions of discoloration. In this study, tree vigor also had a significant impact on the board color classification; less vigorous trees favored regular and red boards over sap boards, meaning that more discoloration was found in boards coming from trees with more external defects.

Results concerning board selection for color showed that the most common category was the sap category, the white clear wood category. This result is consistent with what was established in the first part of this study, where sapwood covered the highest proportion of the board surface (66.7%) when all boards were considered (Drouin et al. 2009). Boards classified as red were infrequent, and this scarcity is reflected on the market by their higher prices (Table 1). These high prices for red boards imply that discolored wood is not necessarily considered undesirable for its appearance by the wood products industry. It is considered problematic when it is simultaneously present with sapwood on the same clear cutting areas as in boards classified as regular on which inconsistent patterns of sapwood and discolored wood appear. When using a raw material classified as regular, the creation of uniformly colored wood products consequently becomes a challenge. Boards classified as red present a uniform red coloration that favors the manufacture of homogeneously colored products, explaining the higher prices. However, its scarcity makes it an interesting raw material, mostly for niche products. Finally, the major price difference between boards selected versus unselected for color allows saying that selecting for color allows recovering considerable revenues and constitutes a real potential for added value.

The results obtained concerning the effect of tree age, diameter, and vigor on board selection for color agreed with results from a previous study (Drouin et al. 2009). This former study established that larger and less vigorous trees produce boards with higher proportions of discolored wood; the effect of tree age is similar, but indirect through tree diameter. These same trees also produced higher proportions of boards classified as red and regular as opposed to sap.

Regarding the lumber value per tree variable, it was influenced the most by tree diameter and tree vigor (MSCR), but not by tree age. As with results concerning grade recovery, larger trees yielded higher lumber value per tree. Tree vigor that did not play an important role on the board quality under the NHLA distribution became a significant variable affecting the board value per tree. This result strengthens the idea that the impact of tree vigor on wood quality seems to be principally on wood color. The more vigorous trees presented more boards classified as sap versus regular boards; therefore, higher values were obtained for these tree vigor classes. It could be that the less vigorous trees presenting more red boards would have helped to increase the lumber value per tree, but the number of boards classified as red was too low to have a clear impact on the total lumber value per tree.

Summary and Conclusions

The objectives of this study were to determine grade recovery, board selection for color, as well as lumber value for paper birch boards and to evaluate the effect of some tree characteristics on these variables.

The effects of tree characteristics on these lumber variables strongly suggest that tree diameter was the most important of the tree variables analyzed. Its influence on the grade recovery and on the lumber value per tree determined that, as tree diameters get larger, the subsequently produced boards tend to reach higher qualities and values. Tree age influence was not as strong but had a certain impact, mainly on grade recovery and board color and, in the same direction as tree diameter. Tree vigor mostly influenced board color and the lumber value per tree, while the most vigorous trees produced more sapwood and higher value boards. Overall, these results tend to support the practice of silvicultural treatments favoring the production of larger stems, such as partial cuttings and, indirectly, longer harvesting rotations; a solution to produce higher value and quality boards. However, it has to be remembered that this solution is also likely to generate a more significant presence of discolored wood in the final material and producing homogeneous final products will be a challenge. Nevertheless, the outcomes concerning the importance of discolored wood and the high prices accorded to the red category suggest considering red heartwood as an asset from an economic perspective, but as a niche product considering its limited volume availability.

This study allowed drawing a general portrait of the value and quality of the sawn boards obtained from two paper birch stands in Québec. Better knowledge on the relationship between tree characteristics and the final product attributes will help to improve decisions in the field of silviculture and raw material requirements for specific end uses. As markets evolve through time, the key is to have better knowledge on the forest resource characteristics in order to use it the best possible way and to be able to select the trees that will be the most appropriate for the final targeted end use because wood quality always depends on the final utilization.

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