forests

MDPI

Article

A Qualitative Analysis of Sawn Timber Obtained from Various Sites Throughout Poland in the Aspect of Polish and European Standards of Quality

Mirski Radosław [1,*], Malinowski Zbigniew [2], Dorota Dziurka [1] and Marek Wieruszewski [1]

1 Department of Wood-based Materials, Faculty of Wood Technology, University of Life Sciences, 60-637 Poznań, Poland; dorota.dziurka@up.poznan.pl (D.D.); marek.wieruszewski@up.poznan.pl (M.W.)
2 Regional Directorate of State Forests in Katowice, 40-543 Katowice, Poland; zbyma@wp.pl
* Correspondence: rmirski@up.poznan.pl

Received: 15 June 2020; Accepted: 25 June 2020; Published: 27 June 2020

check for updates

Abstract: The paper attempts to compare the classification of sawn timber based on the norms used in Poland (PN—75/D—96000) and those valid in the European Union (PN—EN 1611—1). For the research, long pine logs were taken from five research areas in Poland. The obtained sawn materials were divided according to their origin into lengths of the logs. It was shown that regardless of the origin of the stand, knots are the dominant defect, while the role of other wood defects is much lower. Direct comparison of the classification according to Polish and European standards is very difficult due to the differences in the acceptable range of individual wood defects. The raw material classified by the Polish standard shows a higher proportion of sawn timber of higher classes than the one classified by the European standard, so the Polish standard is less rigorous than the European one.

Keywords: sawn pine wood; knots; wood defects; classification

1. Introduction

Scots pine (*Pinus sylvestris* L.) is the essential forest-forming species in Poland: nearly 60% of our forests are pine forests. Most of the 40 million cubic meters of timber harvested in recent years have originated from pine trees. Pine timber has a number of applications, both in the round form (for construction shoring, as pit wood, poles and supports) and as timber [1]. Both these features and the available volume obtained from pine make it the most universally used material in sawmills and wood processing factories in Poland. The technological quality of pine wood is highly varied, depending on the region of Poland it comes from [2]. The qualitative variability of pine wood available in Poland as well as its applicability in industry and for construction purposes has drawn keen attention from researchers from the 1960s. Research works were carried out both by the faculties of forestry (for instance, Paschalis' studies on [3,4] the strength of Polish pine wood) and the faculties of wood technology in various universities, involving the conventional element method [5,6].

The choice of the right sawing method is based on the use of dedicated wood sawing systems [7]. In the final step of sawn timber production, the product is properly sorted. The separation of a certain amount of sawn timber having specific quality or dimensions is based on written product grading criteria (for instance, in the form of standards).

The aspect of proper and more rational utilization of timber in industrial production started to draw specialists' attention in the 1960s [8–11]. Currently, the proper functioning of sawmills and wood processing factories is approached in a more complex way: by acquiring the kind of timber that suits a given production profile, by increasing material efficiency of timber and by reducing production costs. The objective may be attained in several aspects. The technological progress we have been witnessing provides vast opportunities for a very close monitoring of both the wood sawing process, and the whole technological path. Research works on the use of IR, laser-based or radiographic methods are carried out on a large scale [12–14]. Studies on how to improve elimination processes and defect detection are carried out in the wood processing industry, for instance, with the use of industrial computer tomography [15,16]. In 2008, Microtec was the first company to present a prototype CT apparatus, capable of generating images of the inside of timber logs and distribution of defects in it. The applied solution is based on the Feldkamp–Davis–Kress (FDK) algorithm [17].

Knowledge of the structure of timber provides better opportunities to make the most of every log and to handle long logs much better by designing the length of every log, indicating the exact place of cutting it, and by turning every log for storage. Not only the technological but also the economic aspects of using CT are considered in detail [18,19]. The material efficiency of wood enables the assessment of its volume or both its volume and quality required for obtaining specific products [20–23]. The referenced studies pointed out that standardization was a specific system of appraisal of the value of timber and that some problems with identification of the impact of features need to be tackled when using standards related to timber [24–26].

Wood is not a homogeneous material and it varies highly between lots, therefore, multiple problems arise while assessing the quality of wood or wood-based products. Adding to it the numerous standards (national, EU, industry standards), the great number of objects made of wood and the different approaches to the selected features of wood, estimating wood as a material becomes quite a challenge.

This research work compares two methods of sawn timber grading (based on Polish and European standards) for timber obtained from five regions of Poland. The comparison is intended to show similarities and differences encountered in approaching the issue of sawn timber estimation.

2. Materials and Methods

The test material included pine timber from sawing mills in five different locations throughout Poland. The selected tree stands were characterized by comparable conditions of growth (habitat, site index), dimensions and quality so as to be a reference applicable to all Polish pine timber in the form of long logs. For this study, the authors selected pine timber of ages from 88 to 124, from a mixed forest habitat. The timber represented five different natural forest regions (NFR):

- Silesia NFR—Forest Division Olesno (RDLP Katowice);
- Greater Poland and Pomerania NFR—Forest Division Wymiarki (RDLP Zielona Góra);
- Baltic NFR—Forest Division Kalisz Pomorski (RDLP Piła);
- Lesser Poland NFR—Forest Division Dąbrowa Tarnowska (RDLP Kraków);
- Mazovia-Podlasie NFR—Forest Division Biała Podlaska (RDLP Lublin).

Table 1 shows a compilation of forest inventory parameters for selected surfaces. The tree stands were characterized by different tree height and site index and were of comparable technological quality.

Table 1. Details of the areas covered by the study (excerpt from forest management plans).

Forest Division	Age	Height	Site Index	Technological Quality
Olesno	124	25	II	2
Kalisz Pomorski	90	28	I	3
Wymiarki	114	21	III	2
	114	17	IV	2
Biała Podlaska	88	28	I	2
Dąbrowa Tarnowska	90	29	IA	2

Batches of about 50 m^3 of pine wood in the form of long logs were collected from each NFR for the tests. The wood was collected after tree stock survey the purpose of which was to match the qualitative structure (quality class) and dimensional structure (thickness grade) of the wood. The collected data were then analyzed and model trees were determined. This was intended to reflect the average quality and dimensions of pine timber in the form of long logs originating from Polish forests (most of it thickness Grade 2 WC0 material).

The timber was transported to the handling yard before being stored in the form of 3.5 m log logs. All the logs were sawn in the wood processing company KPPD Szczecinek (Koszalińskie Przedsiębiorstwo Przemysłu Drzewnego Spółka Akcyjna).

The sawing process provided edged timber with the nominal dimensions 45 × 140 × 3500 mm, for use in further analyses. The resulting sawn timber was classified according to the Polish Standard concerning coniferous timber for general use [27].

When determining its quality class, a specific board was assessed in terms of acceptable defects of wood. Such defects were categorized, counted, measured and their incidence was described (the incidence of defects on the worse surface and side was assessed). The method comprises two instances of divergence from the rule: (1) when the better surface of a component is free of defects and when the defects present on the worse surface result in the component being graded as Class 2, then the whole component is qualified as Class 1; (2) when there is only one defect and it is the reason why the component must not be graded as Class 2 timber, then the defect is not taken into account. When considering knots, the worse 1.0 m section of sawn timber was analyzed. The resulting sawn timber in the form of boards was graded in separate groups and the results were compiled taking into consideration both the origin of the test material and the type of defect. The resulting timber was graded based on both the Polish and European standards. Moreover, the authors compared both timber grading methods; the one based on the Polish Standard [27] and the European Standard [28].

The outcomes were subjected to statistical analysis. The data were collected using the Excel (2013) spreadsheet and handled by Dixon Q-test to reject outliers. The results were grouped for the whole batch of the material originating from a given site and were compared using the Statistica 13.1 package.

The distribution of the feature of interest was assessed based on the Shapiro–Wilk test. The homogeneity of variance was assessed with the Levene test. To assess the quality of sawn timber, a two-factor ANOVA analysis was performed. Depending on the results of the distribution and variance tests, the significance of the test results was assessed using the ANOVA or the Kruskal–Wallis test. Mean homogeneous groups were separated using the NIR test and Tukey's procedure.

3. Results

The assessment of the quality of sawn timber (according to PN-75/D-96000) obtained from the tested timber indicated variable timber quality depending on its origin. The highest quality was that of the sawn timber obtained from the Forest Divisions Olesno, followed by Wymiarki and Kalisz Pomorski. The sawn timber obtained from the trees from the Forest Divisions Dąbrowa Tarnowska and Biała Podlaska (Figure 1) was of the poorest quality.

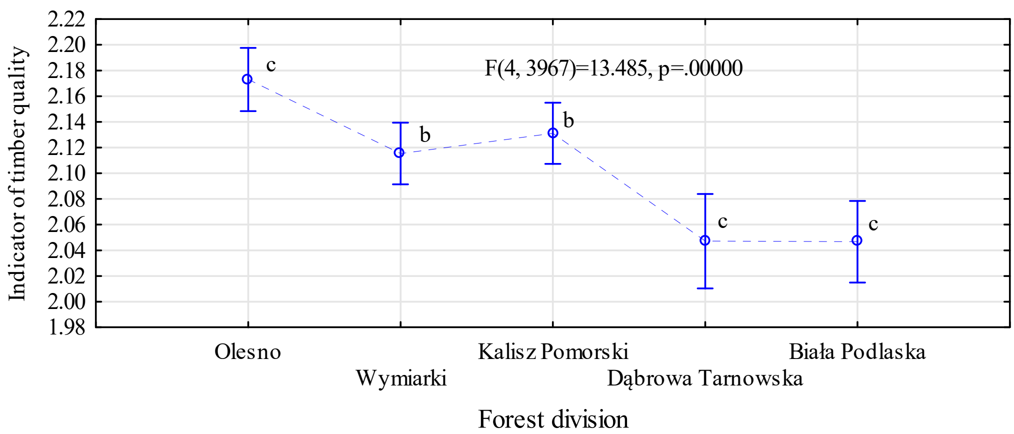

Figure 1. The impact of the origin of long logs on the resulting main timber (lower case letters denote homogeneous groups, as determined by the NIR test).

As regards to the sawn timber quality class, Grade 3 dominated (Table 2). Class 3 timber originated mainly from middle and top logs.

Table 2. The structure of the quality of coniferous sawn timber obtained from the test material according to PN-75/D-96000 for individual forest divisions.

Forest Division	Logs											
	Butt-End Log				Middle Log				Top Log			
	Quality Class											
	I	II	III	IV	I	II	III	IV	I	II	III	IV
	Number of Units											
Olesno	0	93	157	5	2	73	347	11	0	16	158	12
Wymiarki	0	101	221	0	0	26	471	1	0	0	165	3
Kalisz Pomorski	0	116	204	2	0	15	431	0	0	1	179	0
Dąbrowa Tarnowska	5	33	123	6	0	5	340	9	0	2	50	6
Biała Podlaska	4	14	143	5	0	9	321	0	0	1	96	0
TOTAL	9	357	848	18	2	128	1910	21	0	20	648	21

As regards the origin of the material, the percentage of quality Class 4 sawn timber for the top logs was confirmed in the respective sections of the model long logs. A small, but the highest, percentage of sawn timber of higher quality class (including Grade 1) was recorded in the butt-end logs (Figure 2).

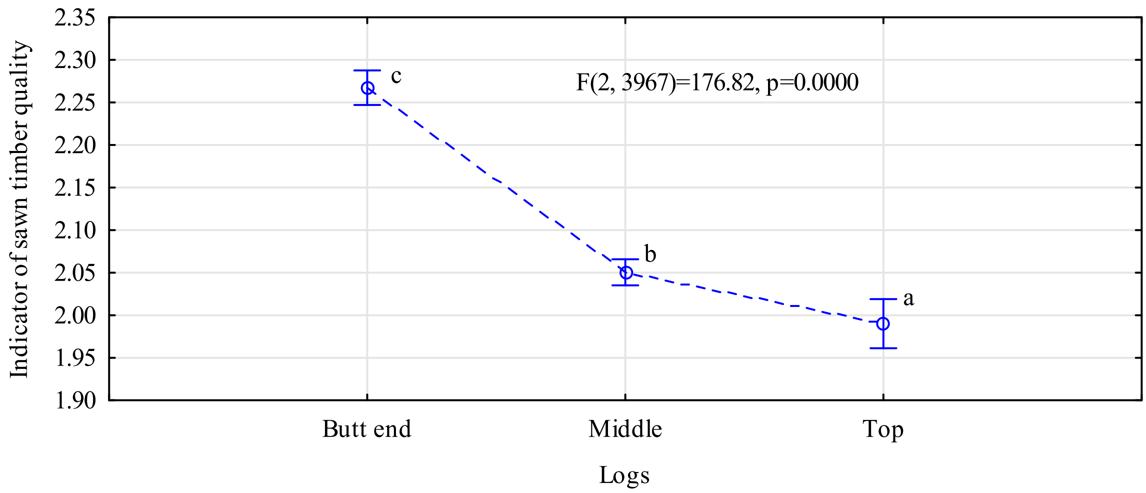

Figure 2. The impact of the origin of logs on the resulting main timber (lower case letters denote homogeneous groups, as determined by the NIR test).

It was observed as a regular feature in sawn timber from all sites that timber of the highest quality was obtained from the butt-end logs, the middle logs were the second best and the top logs were the third-best material. This confirmed the relationships between the exact section of long logs and the quality of the main timber (Figure 3).

Similar results as those for the Polish Standard were obtained using the European Standard PN-EN 1611-1. Grade 3 was the most numerous quality class of the sawn timber. Differences between the two grading procedures related to Grade 4, i.e., the lowest quality class. In the method based on the European standard, the amount of Grade 4 sawn timber was definitely larger. Compared with the method described in the Polish Standard, lower percentages of sawn timber represented, most of all, Grades 1 and 2 (Table 3).

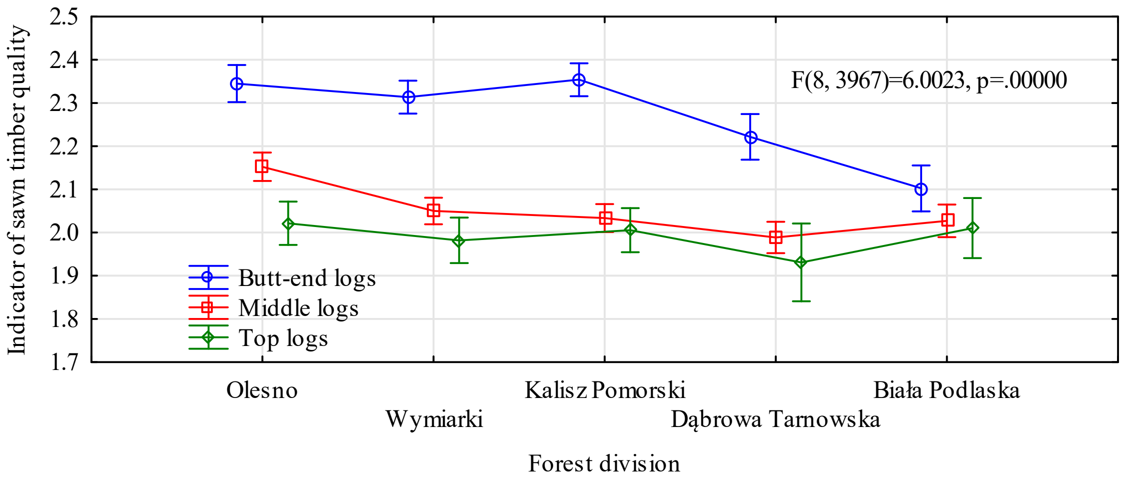

Figure 3. Interactions between the effect of the origin of long logs from a specific geographical region (forest division) and the exact section of long logs on the quality of main timber.

Table 3. The structure of the quality of coniferous sawn timber obtained from the test material according to PN-EN 1611-1 for individual forest divisions.

Forest Division	**Logs**											
	Butt-End Log				**Middle Log**				**Top Log**			
	Quality Class											
	1/0	**2**	**3**	**4**	**1/0**	**2**	**3**	**4**	**1/0**	**2**	**3**	**4**
	Number Units											
Olesno	0	33	135	87	0	35	295	103	0	2	89	95
Wymiarki	0	59	151	112	0	2	312	184	0	0	81	87
Kalisz Pomorski	0	69	168	85	0	6	337	103	0	0	124	56
Dąbrowa Tarnowska	0	23	38	106	0	2	280	72	0	0	35	23
Biała Podlaska	2	6	88	70	0	2	193	135	0	0	52	45
TOTAL	2	190	580	460	0	47	1417	597	0	2	381	306

Among the defects referred to in the standard, knots had a dominant effect on the quality grading of sawn timber regardless of the log zone they came from. The closer the top of the log, the higher the incidence of knots as the determinant of the quality class of sawn timber (Table 4).

Table 4. The percentage of knots as a factor affecting the quality class of sawn timber in the longitudinal section of long logs.

Amount of Sawn Timber	**Logs**		
	Butt-End Log	**Middle Log**	**Top Log**
Total (number units)	1232	2061	689
Logs with knots (number units)	1112	1966	656
Percentage of knots	90	95	95

A similar relationship for the incidence of knots was observed for sawn timber collected separately for each forest division (Table 5).

On the other hand, some differences were also observed. Compared with the other forest divisions, in the sawn timber from the Forest Division Olesno, the incidence of knots in the butt-end logs (as a determinant of its quality class) was the lowest. In the sawn timber from the other forest divisions, the effect of knots as the wood defect on the quality grading of the sawn timber was comparable (Table 6).

Table 5. Amount of sawn timber by defect: knots (PN-75/D-96000).

Forest Division	Logs											
	Butt-End Log				Middle Log				Top Log			
	Quality Class											
	I	II	III	IV	I	II	III	IV	I	II	III	IV
	Number Units											
Olesno	0	77	127	5	0	72	333	11	0	2	155	11
Wymiarki	0	87	204	0	0	26	452	1	0	0	165	3
Kalisz Pomorski	0	113	190	1	0	15	414	0	0	1	173	0
Dąbrowa Tarnowska	0	33	119	2	0	5	327	7	0	2	46	6
Biała Podlaska	0	14	139	1	0	9	294	0	0	1	91	0
TOTAL	0	324	779	9	0	127	1820	19	0	6	630	20

Table 6. The percentage of knots as a factor affecting the quality class of sawn timber in the longitudinal section of long logs for individual forest divisions.

Forest Division	Logs		
	Butt-End Log	Middle Log	Top Log
	(%)		
Olesno	83	97	90
Wymiarki	90	96	100
Kalisz Pomorski	94	96	97
Dąbrowa Tarnowska	92	96	93
Biała Podlaska	93	92	95

Other wood defects considered in the sawn timber quality grading include bark pockets and resin pitches (Table 7).

Table 7. Amount of sawn timber by defect: bark pockets/resin pitches (*PN-75/D- 96000*).

Forest Division	Logs											
	Butt-End Log				Middle Log				Top Log			
	Quality Class											
	I	II	III	IV	I	II	III	IV	I	II	III	IV
	Number Units											
Olesno	0	16	17	0	0	1	14	0	0	14	3	0
Wymiarki	0	14	11	0	0	0	14	0	0	0	0	0
Kalisz Pomorski	0	2	13	0	0	0	15	0	0	0	5	0
Dąbrowa Tarnowska	0	0	0	0	0	0	2	0	0	0	2	0
Biała Podlaska	0	0	1	0	0	0	11	0	0	0	4	0
TOTAL	0	32	42	0	0	1	56	0	0	14	14	0

The effect of bark pockets and resin pitches (considered collectively in PN-75/D-96000) on the quality grading of coniferous sawn timber is definitely less pronounced than that of knots (Table 8). Even though the impact of these two wood defects on its quality grading is rather low, the batches of sawn timber from the various sites differed a lot in this respect.

The most pronounced effect of the bark pockets and resin pitches on quality grading was observed for the sawn timber from the Forest Division Olesno (Table 9). The other two defects considered and identified in the sawn timber did not have much impact on its quality grading. As a result of these defects, a small amount of sawn timber originating from butt-end logs and middle logs was regraded (from Grade 2) to Grade 3 (Tables 10 and 11).

Table 8. The percentage of bark pockets and resin pitches as a factor affecting the quality class of sawn timber in the longitudinal section of long logs.

Amount of Sawn Timber	Logs		
	Butt-End Log	Middle Log	Top Log
Total (pc)	1232	2061	689
With bark pocket and resin pitch (pc)	74	57	28
Percentage of bark pockets and resin pitches	6	3	4

Table 9. The percentage of bark pocket and resin pitch as a factor affecting the quality class of sawn timber in the longitudinal section of long logs for the various forest divisions.

Forest Division	Logs		
	Butt-End Log	Middle Log (%)	Top Log
Olesno	13	3	9
Wymiarki	8	3	0
Kalisz Pomorski	5	3	3
Dąbrowa Tarnowska	0	>1	3
Biała Podlaska	>1	3	4

Table 10. Amount of sawn timber by defect: rot (PN-75/D-96000).

Forest Division	Logs											
	Butt-End Log				Middle Log				Top Log			
	Quality Class											
	I	II	III	IV	I	II	III	IV	I	II	III	IV
	Number Units											
Olesno	0	0	4	0	0	0	0	0	0	0	0	0
Wymiarki	0	0	3	0	0	0	4	0	0	0	0	0
Kalisz Pomorski	0	1	0	0	0	0	0	0	0	0	0	0
Dąbrowa Tarnowska	0	0	2	4	0	0	11	2	0	0	0	0
Biała Podlaska	0	0	1	2	0	0	2	0	0	0	0	0
TOTAL	0	1	10	6	0	0	17	2	0	0	0	0

Table 11. Amount of sawn timber by defect: shakes (PN-75/D-96000).

Forest Division	Logs											
	Butt-End Log				Middle Log				Top Log			
	Quality Class											
	I	II	III	IV	I	II	III	IV	I	II	III	IV
	Number Units											
Olesno	0	0	9	0	0	0	0	0	0	0	0	1
Wymiarki	0	0	3	0	0	0	1	0	0	0	0	0
Kalisz Pomorski	0	0	1	1	0	0	2	0	0	0	1	0
Dąbrowa Tarnowska	0	0	2	0	0	0	0	0	0	0	2	0
Biała Podlaska	0	0	2	2	0	0	14	0	0	0	1	0
TOTAL	0	0	17	3	0	0	17	0	0	0	4	1

The results of verification of the quality of sawn timber based on the European Standard PN-EN 1611-1 were different from those based on the Polish Standard (the two highest grades, Grades 0 and 1 were combined). According to the European grading procedure, the percentage of the lowest grade timber (Grade 4) was the highest. Therefore, a material graded according to the Polish Standard comprises a higher percentage of sawn timber of higher grades than the same material graded based on the European Standard (Figure 4).

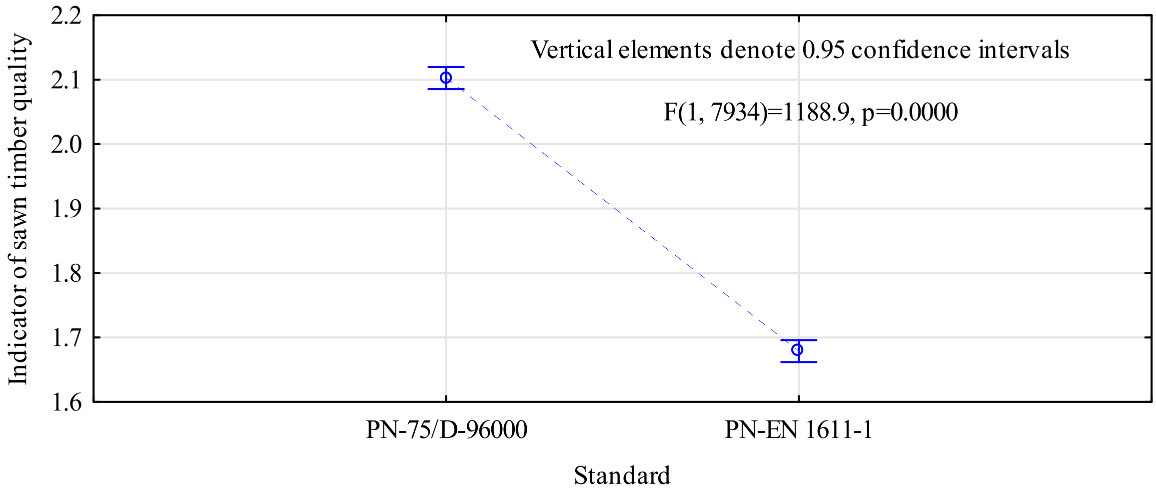

Figure 4. A comparison of average indicators of quality for sawn timber graded according to the Polish Standard (PN-75/D-96000) and the European Standard (PN-EN 1611-1).

A compilation of sawn timbers representing the different quality class according to PN-EN 1611-1 confirmed that its requirements for coniferous timber were higher than those in the Polish Standard *PN-75/96000* (Table 12).

Table 12. The quality grading of coniferous sawn timber according to PN-EN 1611-1 for the various forest divisions.

Log Zone	**Butt-End Log**				**Middle Log**				**Top Log**			
	Number Units											
Quality class	0/1	2	3	4	0/1	2	3	4	0/1	2	3	4
Olesno	0	33	135	87	0	35	295	103	0	2	89	95
Wymiarki	0	59	151	112	0	2	312	184	0	0	81	87
Kalisz Pomorski	0	69	168	85	0	6	337	103	0	0	124	56
Dąbrowa Tarnowska	0	23	38	106	0	2	280	72	0	0	35	23
Biała Podlaska	2	6	88	70	0	2	193	135	0	0	52	45
TOTAL	2	190	580	460	0	47	1417	597	0	2	381	306

Such higher requirements resulted in the sawn timber being graded lower that the material graded based on the European Standard related to sawn timber from all the sites (Figure 5).

As in PN-75/D-96000, knottiness was the defect with the highest impact on the quality grading of the sawn timber regardless of the log zone it came from, and such impact was noticeably lower than in the case of the Polish Standard (Table 13).

The same regularity was observed for the sawn timber originating from the respective forest divisions. The impact of knots as wood defect on the grading of sawn timber from the other forest divisions was comparable (Tables 14 and 15).

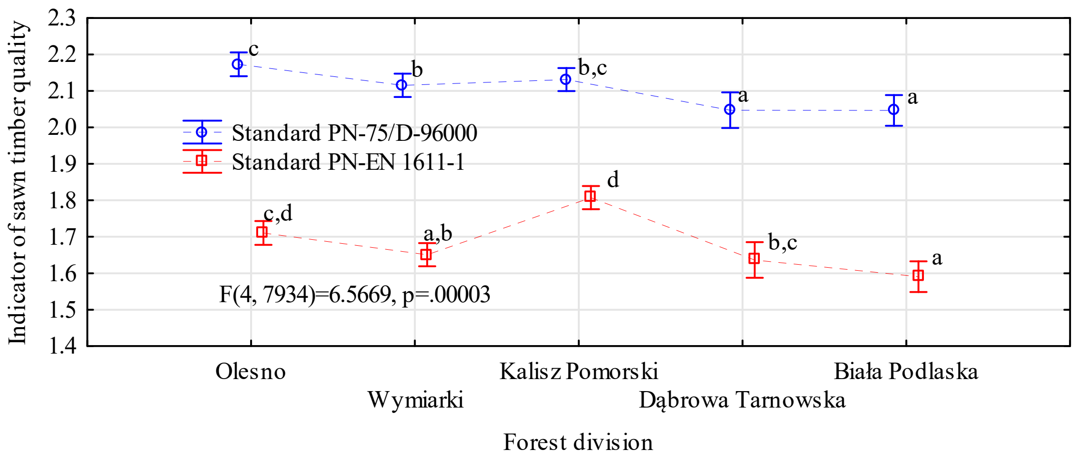

Figure 5. A comparison of the quality of sawn timber graded based on the Polish Standard and the European Standard for timber from different sites (the letters denote homogeneous groups as found in the Tukey's test for different forest divisions).

Table 13. The percentage of knots as a factor affecting the quality class of sawn timber in the longitudinal section of long logs.

Amount of Sawn Timber	**Logs**		
	Butt-End Log	**Middle Log**	**Top Log**
Total (pc)	1232	2061	689
Logs with knots (pc)	952	1513	629
Percentage of knots	77	73	91

Table 14. Amount of sawn timber by defect: knots (PN-EN 1611-1).

Forest Division	**Logs**											
	Butt-End Log				**Middle Log**				**Top Log**			
	Quality Class											
	0/1	**2**	**3**	**4**	**0/1**	**2**	**3**	**4**	**0/1**	**2**	**3**	**4**
	Number Units											
Olesno	0	14	96	76	0	34	193	86	0	2	84	94
Wymiarki	0	24	119	107	0	2	197	162	0	0	75	87
Kalisz Pomorski	0	44	115	84	0	4	242	84	0	0	101	56
Dąbrowa Tarnowska	0	18	34	79	0	2	217	34	0	0	19	23
Biała Podlaska	2	5	81	54	0	2	157	97	0	0	43	45
TOTAL	2	105	445	400	0	44	1006	463	0	2	322	305

Table 15. The percentage of knots as a factor affecting the quality class of sawn timber in the longitudinal section of long logs for the various forest divisions.

Forest Division	**Logs**		
	Butt-End Log	**Middle Log**	**Top Log**
	(%)		
Olesno	73	72	97
Wymiarki	78	72	96
Kalisz Pomorski	75	74	87
Dąbrowa Tarnowska	78	71	72
Biała Podlaska	85	77	91

Other types of wood defects considered in the sawn timber quality grading were bark pockets and resin pitches. In comparison with the Polish Standard, such defects had a considerable impact on the sawn timber quality grading. Specifically, this related to the sawn timber obtained from the middle sections of long logs (Table 16).

Table 16. The percentage of bark pockets and resin pitches as a factor affecting the quality class of sawn timber in the longitudinal section of long logs.

Amount of Sawn Timber	Logs		
	Butt-End Log	Middle Log	Top Log
Total (pc)	1232	2061	689
With bark pocket and resin pitch (pc)	244	512	55
Percentage of bark pockets and resin pitches	20	25	8

These defects were observed regularly in the sawn timbers from all forest divisions (Table 17). Bark pockets and resin pitches have the most undesirable effect on the quality grading of sawn timber from the middle sections of long logs. For the various forest divisions, the defect spanned from 18% to 28% for the Forest Divisions Biała Podlaska and Olesno, respectively (Table 18).

Table 17. Amount of sawn timber by defect: bark pockets/resin pitches (PN-EN 1611-1).

Forest Division	Logs											
	Butt-End Log				Middle Log				Top Log			
	Quality Class											
	0/1	2	3	4	0/1	2	3	4	0/1	2	3	4
	Number Units											
Olesno	0	19	37	0	0	1	102	17	0	0	5	0
Wymiarki	0	35	31	0	0	0	115	17	0	0	6	0
Kalisz Pomorski	0	24	52	0	0	2	95	17	0	0	22	0
Dąbrowa Tarnowska	0	5	2	21	0	0	54	34	0	0	14	0
Biała Podlaska	0	1	6	11	0	0	34	24	0	0	8	0
TOTAL	0	84	128	32	0	3	400	109	0	0	55	0

Table 18. The percentage of bark pocket and resin pitch as a factor affecting the quality class of sawn timber in the longitudinal section of long logs for the various forest divisions.

Forest Division	Logs		
	Butt-End log	Middle log	Top log
	(%)		
Olesno	22	28	3
Wymiarki	20	26	4
Kalisz Pomorski	24	26	12
Dąbrowa Tarnowska	17	25	24
Biała Podlaska	11	18	8

The other two defects considered and identified in the sawn timber did not have much impact on its quality grading. They resulted in a small amount of sawn timber originating from all sections of long logs having to be regraded from Grade 3 to Grade 4, and were the most numerous in the butt-end- and middle logs (Tables 19 and 20).

Table 19. Amount of sawn timber by defect: rot (PN-EN 1611-1).

Forest Division	Logs											
	Butt-End Log				Middle Log				Top Log			
	Quality Class											
	0/1	2	3	4	0/1	2	3	4	0/1	2	3	4
	Number Units											
Olesno	0	0	0	4	0	0	0	0	0	0	0	0
Wymiarki	0	0	0	3	0	0	0	4	0	0	0	0
Kalisz Pomorski	0	1	0	3	0	0	0	4	0	0	0	0
Dąbrowa Tarnowska	0	0	0	6	0	0	9	4	0	0	0	0
Biała Podlaska	0	0	0	3	0	0	2	0	0	0	0	0
TOTAL	0	1	0	19	0	0	11	12	0	0	0	0

Table 20. Amount of sawn timber by defect: shakes (PN-EN 1611-1).

Forest Division	Logs											
	Butt-End log				Middle log				Top log			
	Quality Class											
	0/1	2	3	4	0/1	2	3	4	0/1	2	3	4
	Number Units											
Olesno	0	0	2	7	0	0	0	0	0	0	0	1
Wymiarki	0	0	1	2	0	0	0	1	0	0	0	0
Kalisz Pomorski	0	0	1	1	0	0	0	2	0	0	1	0
Dąbrowa Tarnowska	0	0	2	0	0	0	0	0	0	0	2	0
Biała Podlaska	0	0	1	2	0	0	0	14	0	0	1	0
TOTAL	0	0	7	12	0	0	0	17	0	0	4	1

In assessing the quality of pine timber, knots play a decisive role: they affect the quality of timber, graded in accordance with comparable Polish and European standards. As a result, the sawn timber is regraded, usually from Grade 3 under the Polish Standard to Grade 4 under the European Standard, or from Grade 2 to Grade 3.

Even after regrading, the presence of bark pockets and resin pitches is another important factor to be taken into account in assessing the quality of the sawn timber. These defects lead to less sawn timber being classified as Grade 2 or Grade 3 material.

Comparing the quality classes of sawn timber under the Polish Standard and the European Standard, one can observe that the same sawn timber represents different quality classes when classified according to different quality standards. The Polish Standard provides potentially higher quality classes than the European Standard. This regularity is best illustrated by comparing graphs showing quality classes for sawn timber originating from the butt-end, middle and top logs (Figure 6). The European Standard emphasizes not only the presence of knots—the essential defect of sawn timber—but also the resin pitches that strongly and negatively affect gluing and surface finishing processes. The Polish Standard refers only to knots in sawn timber whereas the other defects (including resin pitches) have a marginal effect on the quality class of sawn timber, under the Polish Standard.

The graph showing the quality of sawn timber graded under the Polish Standard has a regular profile (Figure 6a). The quality of the sawn timber has a regular shape depending on the section of the long log it comes from. Sawn timber of the highest quality comes from the butt-end logs and the top logs provide timber of the poorest quality, whereas middle-quality timber is obtained from the middle logs. Such shape of the curve relates to sawn timber from every forest division. The curve showing the same relationship based on the European Standard for the various forest divisions had quite a different shape. For two forest divisions, namely Wymiarki and Kalisz Pomorski, the regular curve profile was maintained. For the forest divisions Olesno and Dąbrowa Tarnowska, the sawn timber of the best quality class came from the middle logs. On the other hand, in the forest division Olesno, sawn timber of the lowest quality class came from the top logs, and in Dąbrowa Tarnowska from the butt-end logs. In the sawn timber from the forest division Biała Podlaska, the arrangement of the quality classes of sawn timber was quite similar to that resulting from the Polish Standard, although the distances between the indicators of the quality of sawn timber obtained from the various log zones were not very large. Small differences between the indicators of quality for sawn timber were seen also in the method based on the Polish Standard. The reason why this occurred was probably that timber from that very site had the highest percentage of knots in its butt-end and middle sections.

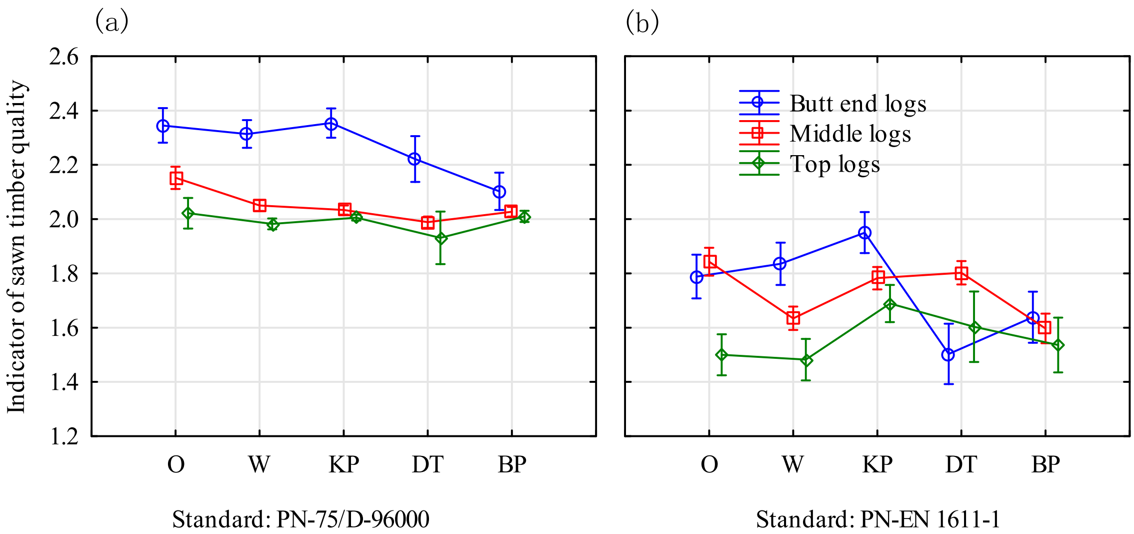

Figure 6. Quality classes for sawn timber from butt-end, middle and top logs, graded according to the Polish Standard (PN-75/D-96000) (**a**) and the European Standard (PN-EN 1611-1) (**b**).

4. Conclusions

In some aspects, the implementation of the common European legislation in certain sectors of the Polish economy is not very smooth, even though Poland has been a member of the European Union since 2004. Among other things, this relates to wood as a material in the roundform and as processed wood, including timber. The Polish State Forests—the principal supplier of roundwood in Poland—follows its internal wood grading rules, based on the order of the Director-General of the State Forests defining the applicable technical requirements. In this respect, Poland is no exception among the EU states: some of them also have their own rules of standardization and quality grading of wood [29]. Despite some important dissimilarities between Poland and the European Union or any other EU member state, the grading rules applied have one thing in common, namely, wood defects. The timber quality grading rules depend on the acceptable range of intensity of these features (defects) according to any applicable national or European standard. Unfortunately, it would not be acceptable to use either the national or the European standards for timber quality grading. Timber quality grading is based on different methods of assessment of the defects and their acceptability. According to the examples shown above, the use of European standards in the quality grading of Polish coniferous timber results in a more stringent classification, especially as regards the higher quality grades. This is because the requirements of European Standards relating to knots and resinosis are more severe, in the first place. Even though the common economic and political space in Europe does exist, some regional (national) conditions in the European Union continue to prevail, and it is hard to predict when technical requirements and standards related to wood (and wood-based products, including sawn timber) in the whole European Union will be harmonized, if at all.

Author Contributions: Conceptualization, M.Z., M.W. and M.R.; methodology, M.Z., and M.R.; validation, M.Z., M.W. and D.D.; formal analysis, M.Z. and. M.R.; investigation, M.Z. and M.W; resources, M.Z. and D.D.; writing—original draft preparation, M.Z., M.R. and M.W.; writing—review and editing, D.D. and M.R.; visualization, D.D.; supervision, D.D.; project administration, M.R.; funding acquisition, M.R. and M.W. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by the National Centre for Research and Development, BIOSTRATEG3/344303/14/NCBR/2018. The authors are grateful for the support of the Ministry of Science and Higher Education program "Regional Initiative of Excellence" in the years 2019–2022, Project No. 005/RID/2018/19.

Conflicts of Interest: The authors declare no conflicts of interest.

References

1. Şevik, H.; Topaçoğlu, O. Variation and inheritance pattern in cone and seed characteristics of Scots pine (*Pinus sylvestris* L.) for evaluation of genetic diversity. *J. Environ. Biol.* **2015**, *36*, 1125–1130. [PubMed]
2. Laurow, Z. *Co Brakarz Wiedzieć Powinien*; Wydawnictwo Świat: Warsaw, Poland, 1994.
3. Paschalis-Jakubowicz, P.; Kulik, P.; Lachowicz, H. Obrót surowcem drzewnym najwyższych klas jakości w Polsce. Sales of the timber in the highest quality class in Poland. *Sylwan* **2015**, *159*, 91–102.
4. Paschalis-Jakubowicz, P.; Kulik, P.; Lachowicz, H. Potencjalna ilość surowca drzewnego najwyższych klas jakości w Polsce. Potential volume of the highest quality timber in Poland. *Sylwan* **2015**, *159*, 188–200. [CrossRef]
5. Oktaba, J.; Paschalis, P.; Staniszewski, P. Selected indicators of pine and spruce wood technical quality from the forest being under the influence of industrial pollution. Folia Forestalia Polonica 2002. *Ser. A For.* **2002**, *44*, 77–86.
6. Mirski, R.; Wieruszewski, M.; Malinowski, Z. Zmienność rozkładu wad drewna okrągłego w dojrzałych drzewostanach sosnowych. *Sylwan* **2019**, *163*, 913–923. [CrossRef]
7. PIGPD. *Vademecum przetarcia drewna okrągłego*; Polska Izba Gospodarcza Przemysłu Drzewnego: Poznań, Poland, 2018.
8. Dziewanowski, R. Analiza porównawcza jakości tartacznego drewna sosnowego Krainy Mazursko-Podlaskiej na tle kolei rębności. *Sylwan* **1961**, *4*, 31–54.
9. Nasir, V.; Cool, J. A review on wood machining: Characterization, optimization, and monitoring of the sawing process. *Wood Mater. Sci. Eng.* **2018**. [CrossRef]
10. Gotych, V.; Hruzik, G.J.; Wieruszewski, M. The efficiency of processing the lateral sawn timber of pine on elements to the production of the glued of beams. *Intercathedra* **2011**, *27*, 20–23.
11. Stöd, R.; Verkasalo, E.; Heinonen, J. Quality and Bending Properties of Sawn Timber from Commercial Thinnings of Scots Pine (*Pinus sylvestris* L.). *Balt. For.* **2016**, *22*, 148–162.
12. Krzosek, S. Przegląd technik tartacznych stosowanych w halach przetarcia w polskich tartakach. *Rynek Drzewny. Biuletyn Polskiej Izby Gospodarczej Przemysłu Drzewnego* **2012**, *1*, 9–11.
13. Pyorala, J.; Kankare, V.; Liang, X. Assessing log geometry and wood quality in standing timber using terrestrial laser-scanning point clouds. *Forestry* **2018**, *92*, 177–187. [CrossRef]
14. Siekański, P.; Magda, K.; Malowany, K.; Rutkiewicz, J.; Styk, A.; Krzesłowski, J.; Kowaluk, T.; Zagórski, A. On-Line Laser Triangulation Scanner for Wood Logs Surface Geometry Measurement. *Sensors* **2019**, *19*, 1074. [CrossRef] [PubMed]
15. Brüchert, F.; Sauter, U.H. Was leisten Röntgentechnologie und Computertomographie für die Optimierung der Forst-Holz-Kette? *AFZ Der Wald* **2011**, *10*, 24–26.
16. Fredriksson, M.; Cool, J.; Avramidis, S. Automatic Knot Detection in Coarse-Resolution Cone-Beam Computed Tomography Images of Softwood Logs. *For. Prod. J.* **2019**, *69*, 185–187.
17. Giudiceandrea, F.; Ursela, E.; Vicario, E. A high Speed CT scanner for the sawmill industry. In Proceeding of the 17th International Nondestructive Testing and Evaluation of Wood Symposium, Sopron, Hungary, 14–16 September 2011.
18. Rummukainen, H.; Makkonen, M.; Uusitalo, J. Economic value of optical and X-ray CT scanning in bucking of Scots pine. *Wood Mater. Sci. Eng.* **2019**. [CrossRef]
19. Pernkopf, M.; Riegler, M.; Gronalt, M. Profitability gain expectations for computed tomography of sawn logs. *Eur. J. Wood Prod.* **2019**, *77*, 619–631. [CrossRef]

20. United States Forest Products Laboratory, USDA Forest Service Wood Handbook—Wood as an Engineering Material. General Technical Report 113. Forest Products Society 1999, Madison, Wis. Available online: http://www.fpl.fs.fed.us/documnts/fplgtr/fplgtr113/fplgtr113.pdf (accessed on 20 June 2020).
21. Bowyer, J.L.; Shmulsky, R.; Haygreen, J.G. *Forest Products and Wood Science: An Introduction*, 5th ed.; Blackwell Publishing: Oxford, UK, 2007.
22. Buchholz, J.; Hruzik, J.G.; Meyer, B. Badania wybranych właściwości sosnowego drewna tartacznego pochodzącego z baz surowcowych objętych szkodami leśnymi. *Folia For. Pol. Seria B* **1990**, *21*, 17–31.
23. Niemistö, P.; Kilpeläinen, H.; Poutiainen, E. Effect of first thinning type and age on growth, stem quality and financial performance of a Scots pine stand in Finland. *Silva Fenn.* **2018**, *52*, 7816. [CrossRef]
24. Tomczak, A.; Pazdrowski, W.; Jelonek, T.; Grzywiński, W. Jakość drewna sosny zwyczajnej (Pinus sylvestris L.) Część I. Charakterystyka wybranych cech i właściwości drewna wpływających na jego jakość. *Sylwan* **2009**, *153*, 363–372.
25. Jelonek, T.; Pazdrowski, W.; Tomczak, A.; Szaban, J. The effect of social position of a tree in the stand and site on wood quality of scots pine (*Pinus sylvestris* L.). *Electron. J. Pol. Agric. Univ.* **2008**, *11*, 10. Available online: http://www.ejpau.media.pl/volume11/issue2/art-10.pdf (accessed on 20 June 2020).
26. Ballaun, A. Rynek drzewny w aspekcie wprowadzenia procesu kłodowania drewna oraz norm europejskich na surowiec drzewny. *Rynek drzewny* **1999**, *3*, 20–24.
27. PN-75/D-96000. *General purpose coniferous timber (in Polish)*; Polish Committee for Standardization: Warsaw, Poland, 1978.
28. PN-EN 1611-1. Sawn timber—appearance grading of softwoods. Part 1. In *European Spruces, Firs, Pines and Douglas Firs*; European Committee for Standardization: Brussels, Belgium, 2002.
29. Malinowski, Z.; Wieruszewski, M. Comparison of the large−size wood defects in the European Union countries normalization. *Sylwan* **2017**, *10*, 795–803. (In Polish) [CrossRef]