

## Timber prices after natural disasters in the Forest District of Węgierska Górk

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**Abstract.** The aim of the study was to determine the impact of increased timber logging after natural disasters on timber assortments, unit prices, as well as average prices of timber spruce and total timber. The net sales prices of the years 2004–2010, available from the database of the State Forests Information System (SFIS) for the Forest District of Węgierska Górk, were analysed and compared to the prices of selected forest districts within the Regional Directorate of State Forests in Cracow (RDSF). The forest districts were classified based on the volume of logged timber leading to a separation into two groups of two and six forest districts. Moreover, we tested for significance in the linear trends of relevant characteristics and determined confidence intervals. Furthermore, we calculated the rate of growth (decrease) of the unit prices. Our studies show a decrease in price of only some of the timber assortments despite a significantly increased supply. Price declines were observed for the average prices of timber spruce and total timber due to their lowered quality. The price of timber assortments was mainly determined by effects of macroeconomic factors.

**Key words:** natural disasters, timber assortments, unit prices, the timber market

### 1. Introduction

Natural disasters in forests can be caused by various factors such as anthropogenic (wildfires), biotic (insects) and also abiotic (hurricane). From an economic point of view, such disasters result in damages, which have significant consequences for forest economy usually expressed in area damaged by the disaster or the volume of destroyed timber. Less often, such disasters are expressed in financial characteristics such as losses or foregone benefits, and sometimes as additional costs related to unplanned management activities.

In the Beskid Mountains, first indications of spruce forest dieback due to industrial emissions were observed in 1950s. As a consequence of emission effect, soil quality started to decrease and natural resistance of trees was also being lost. Damages from biotic factors, mainly pathogenic fungi, were on the rise. In the

end, a combination of unfavourable climatic conditions during the last decade, which mainly included droughts and hurricanes in 2004 and 2007, culminated in European spruce bark beetle (*Ips typographus*) outbreak and dieback of spruce stands (Szabla 2009; Bruchwald and Dmyterko 2010; Grodzki 2012). As a consequence of negative circumstances related to natural disasters, large-diameter timber volumes planned to be harvested in the years 2004–2013 in Forest District of Węgierska Górk were already surpassed in 2009. Furthermore, the average volume per hectare decreased from 354 m<sup>3</sup>/ha in 2006 to 132 m<sup>3</sup>/ha in 2009, while average age decreased from 73 years in 2006 to 47 years (Aneks do Planu Urządzenia Lasu na lata 2004–2013 dla Nadleśnictwa Węgierska Górk, 2009). The development of timber market in the conditions affected by natural disasters is not sufficiently covered by the existing literature. However, according to Ratajczak and Splawa-Neyman

(1997), harvesting of large timber volumes during short time periods usually results in destabilisation and unrest of timber markets and causes decrease of prices. Similar opinions could be found in the study by Baur et al. (2003) and Svensson et al. (2011). Prestemon and Holmes (2010) described three phases that timber prices follow after a natural disaster. The first phase is the decrease of timber prices, second phase is the increase of prices and the third one is the return of timber prices to pre-storm levels. Profits from timber sales largely depend on timber quality, which could deteriorate as a result of natural disaster (among others, Nieuwenhuis and O'Connor 2001; Nieuwenhuis and Fitzpatrick 2002; Kaliszewski 2009).

The goal of the current study is to determine the effect of increased timber volumes salvaged after natural disasters on timber price dynamics for selected timber grades, and also on average prices of spruce timber and overall timber prices in the Forest District of Węgierska Górka in the years 2004–2010.

## 2. Study area

The dieback of spruce forest stands has been observed in the Forest District of Węgierska Górka (Fig. 1) in the Beskid Mountains area of the Regional Directorate of the State Forests in Katowice. The forests of the Forest District of Węgierska Górka cover an area of 9366.2 hectares (data on 31.12.2010). The total area within the borders of the forest district is 28,986 hectares, which includes 48.4% of forests of different ownership types (Aneks do Planu Urządzenia Lasu na lata 2004–2013 dla Nadleśnictwa Węgierska Górka, 2009). According to the regional nature and forest classification of Poland

by Trampler and others (1990), the Forest District of Węgierska Górka is located in the Beskid Śląski and Beskid Żywiecki sections. Geophysical classification of Kondracki (2002) situates the forest district in the Western Carpathians province and Beskid Śląski, Beskid Żywiecki and Kotlina Żywiecka basin mezoregions.

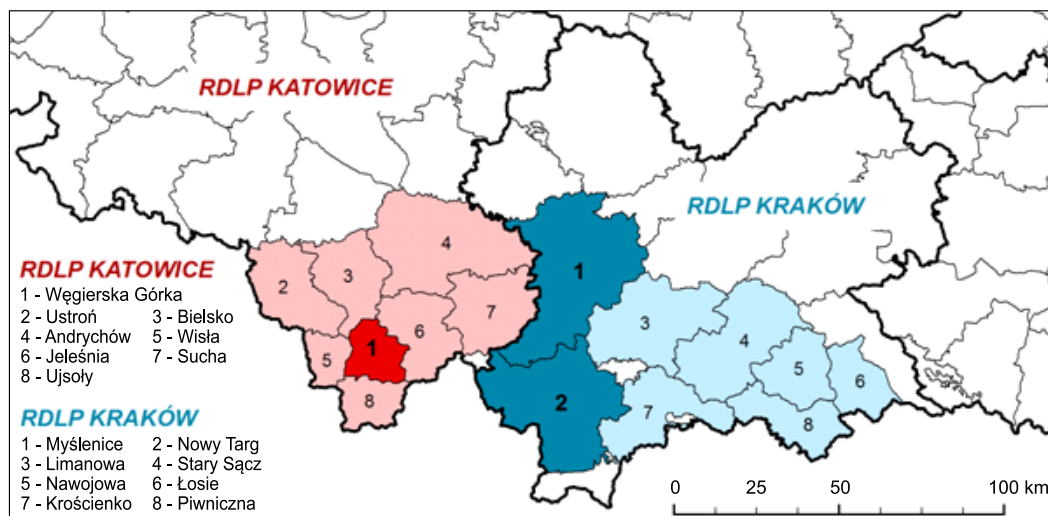
Economic consequences of natural disasters in the Forest District of Węgierska Górka were compared with forest districts with similar geophysical, natural and economic conditions and located to the east in the Regional Directorates of the State Forests in Kraków, Krościenko, Limanowa, Łosie, Myślenice, Nawojowa, Nowy Targ, Piwniczna and Stary Sącz (Fig. 1). The listed forest districts covered a total area of 83,733.07 hectares (as of 31.12.2010). The Forest District of Węgierska Górka has a large share of Norway spruce (*Picea abies*), which amounts to 88% (as of 31.12.2006) in contrast with other studied forest districts where spruce covers from 5% (in Łosie Forest District) to 57% (in Nowy Targ Forest District).

## 3. Research methods

### Analysis of unit prices of various timber grades and average prices of raw timber

The analysis covered five selected spruce timber grades. Their combined share in total timber sale of the Forest District of Węgierska Górka varied from 88% in 2010 to 96% in 2007 (Table 1), and specifically:

- large-diameter timber of the C-class quality (PLN/m<sup>3</sup>). The analysis covered jointly the timber of general use 'WCO' and timber of special use 'WC1' in their different diameter classes (PN-93/D-02002 and PN-D-95000),



**Figure 1.** Forestry Districts of Beskid Śląski and Żywiecki in RDSFs in Katowice and selected forest districts in RDSFs in Kraków (Forest Digital Map 2010)

**Table 1.** The timber volume (m<sup>3</sup>) and share (%) of sales for selected assortments of timber in the Forest District of Węgierska Górká in the years 2004–2010

Assortment	Years													
	2004		2005		2006		2007		2008		2009		2010	
	m <sup>3</sup>	%	m <sup>3</sup>	%	m <sup>3</sup>	%	m <sup>3</sup>	%	m <sup>3</sup>	%	m <sup>3</sup>	%	m <sup>3</sup>	%
ŚW_WA <sup>1</sup>	372.04	0.35	390.52	0.32	568.74	0.31	621.34	0.24	244.95	0.09	174.22	0.08	39.91	0.05
ŚW_WB <sup>2</sup>	2 850.81	2.68	3 118.08	2.57	2 591.98	1.40	3 568.30	1.35	1 998.31	0.74	2 785.42	1.29	973.91	1.27
ŚW_WC <sup>3</sup>	49 604.08	46.61	51 467.00	42.48	73 246.85	39.61	103 429.61	39.14	83 097.64	30.83	83 356.37	38.58	2 5132.60	32.80
ŚW_WD <sup>4</sup>	21 324.97	20.04	23 718.44	19.58	44 018.40	23.80	83 319.29	31.53	87 878.44	32.59	45 144.95	20.89	11 205.66	14.62
ŚW_S2a <sup>5</sup>	16 086.62	15.12	18 228.76	15.05	22 095.07	11.95	19 208.08	7.27	23 545.58	8.73	19 610.99	9.08	6 636.61	8.66
ŚW_S2b <sup>6</sup>	8 904.40	8.37	18 203.39	15.03	30 055.81	16.26	42 237.34	15.99	58 108.95	21.56	50 119.27	23.19	17 904.55	23.37
ŚW_S3b <sup>7</sup>	233.71	0.22	190.66	0.16	145.16	0.08	127.49	0.05	269.13	0.10	208.67	0.10	158.52	0.21
ŚW_S4 <sup>8</sup>	3 484.86	3.28	3 542.86	2.92	6 315.24	3.42	6 077.04	2.30	6 820.66	2.53	8 797.75	4.07	6 012.87	7.85
Others <sup>9</sup>	3 542.87	3.33	2 289.14	1.89	5 857.52	3.17	5 638.05	2.13	7 662.01	2.83	5 886.86	2.72	8 559.44	11.17
Total	106 404.36	100.00	121 148.85	100.00	184 894.77	100.00	264 226.54	100.00	269 625.67	100.00	216 084.50	100.00	76 624.07	100.00

<sup>1</sup> large-sized assortment of spruce grade A (including logs and special timber in various classes of thicknesses)<sup>2</sup> large-sized assortment of spruce grade B (including logs and special timber in various classes of thicknesses)<sup>3</sup> large-sized assortment of spruce grade C (including logs and special timber in various classes of thicknesses)<sup>4</sup> large-sized assortment of spruce grade D in various classes of thicknesses<sup>5</sup> medium-sized assortment of spruce grade S2a (including pulp-wood regardless of the destination in various classes of length)<sup>6</sup> medium-sized assortment of spruce grade S2b (including pulp-wood regardless of the destination in various classes of length)<sup>7</sup> medium-sized assortment of spruce grade S3b (including pulp-wood in various classes of dimension)<sup>8</sup> medium-sized assortment of spruce grade S4 (including large size of fire-wood)<sup>9</sup> timber of other trees species without specifying assortments

Source: Own study based on reports from SFIS database for the Forest District of Węgierska Górká

**Table 2.** Timber logging in the Forest District of Węgierska Górką and selected forest districts in the years 2004–2010 (thousand m<sup>3</sup>)

Forest District	Logging in the years (thousand m <sup>3</sup> )						
	2004	2005	2006	2007	2008	2009	2010
Krościenko	35.11	31.65	35.80	34.39	34.83	26.54	38.76
Limanowa	31.57	33.96	34.03	37.78	36.62	36.88	36.35
Łosie	65.60	59.50	58.40	60.60	65.32	64.13	71.08
Myślenice	44.03	80.10	46.57	46.81	46.68	56.63	55.32
Nawojowa	41.79	40.77	40.40	40.10	40.54	40.36	56.20
Nowy Targ	42.46	70.61	42.11	48.49	37.50	37.53	37.31
Piwniczna	53.83	51.46	51.98	51.65	43.56	53.09	61.82
Stary Sącz	25.24	19.87	32.71	38.67	40.14	38.84	39.08
Węgierska G.	104.76	125.41	182.81	278.32	263.03	211.87	74.97

Source: Own study based on the State Forests database

- large-diameter timber of the D-class quality (PLN/m<sup>3</sup>). The analysis covered jointly timber in different diameter classes (PN-93/D-02002 and PN-D-95000),

- medium-diameter timber of the S2a group (PLN/m<sup>3</sup>). The analysis covered jointly piled timber of various use and length (PN-93/D-02002 and PN-D-95000),

- medium-diameter timber of the S2b group (PLN/m<sup>3</sup>). The analysis covered jointly piled timber of various use and length (PN-93/D-02002 and PN-D-95000),

- medium-diameter timber of the S4 group (PLN/m<sup>3</sup>), the so-called large firewood (PN-93/D-02002 and PN-D-95000).

Net sale prices from given year of the 2004–2010 period were analysed. The analysis also covered average prices of spruce timber in general received from the sale of all spruce timber grades. In addition, average price of timber obtained from the sale of all timber grades was studied. State Forests Information System SFIS (SILP) was used as the source of information on prices.

### Statistical analysis

The Forest District of Węgierska Górką and districts compared with it differed from one another by harvested timber volumes in given years of the study period (Table 2). The hierarchical cluster analysis was conducted using a method of single-linkage clustering (Florek et al. 1951) and the Euclidean distance as a measure of distance between observations. Two sets of forest districts with similar harvested timber volumes were identified among the compared forest districts: 1) Krościenko and Limanowa, Stary Sącz, Nawojowa, Piwniczna and Łosie (the set of six forest districts), and 2) Myślenice and Nowy Targ (the set of two forest districts).

Statistical analysis of economic parameters was based on the adopted grouping of compared units. The confidence interval corresponding to the significance level with the value of  $p=0.05$  was chosen for six forest districts in the calculation of the mean in various years. Whereas, only average values were calculated for the remaining two forest districts due to small size of the sample. The significance of linear trends of the analysed characteristics of the two sets of forest districts was studied using an F-test. The analysis was implemented using statistical package STATISTICA 10.0 (StatSoft 2011).

The rate of growth (decline) was calculated to describe changes in unit prices of various timber grades, as well as mean prices of all spruce timber grades and timber in general.

### 4. Results

In 2004–2008, unit prices of large-diameter spruce timber of the C-class quality (WC) in the Forest District of Węgierska Górką were from 3.12 PLN/m<sup>3</sup> (in 2004) to 21.68 PLN/m<sup>3</sup> (in 2008), which are respectively 1.5% and 9.5% lower than prices in the set comprised of six forest districts (Fig. 2). In 2009 and 2010, the situation was the opposite and the prices were higher on 5.04 PLN/m<sup>3</sup> and 15.49 PLN/m<sup>3</sup>, which are 2.5% and 7% higher. Comparing with the set of two forest districts, the prices of the above timber grade in the Forest District of Węgierska Górką were 3.8% and 12.5% or 7.97 PLN/m<sup>3</sup> (in 2004)

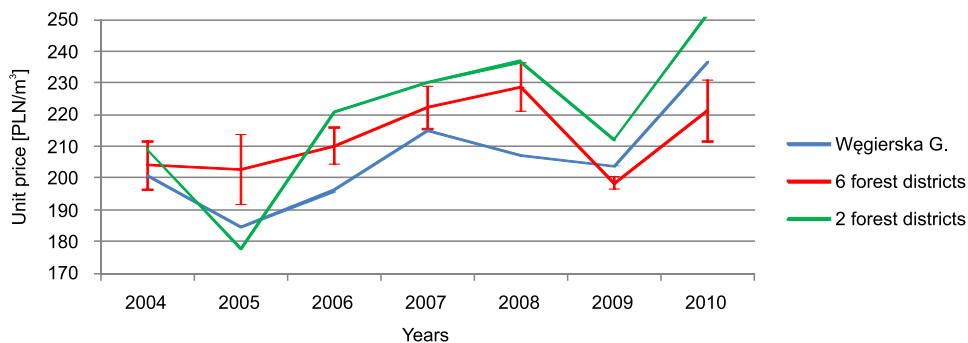
and 29.69 PLN/m<sup>3</sup> (in 2008) lower. The exception was in 2005 when the price was 7.05 PLN/m<sup>3</sup> or 4% higher.

The analysis did not find a statistically significant ( $p > 0.05$ ) linear trend for unit prices of the WC timber grade in the Forest District of Węgierska Górka and in other studied forest districts (Fig. 2).

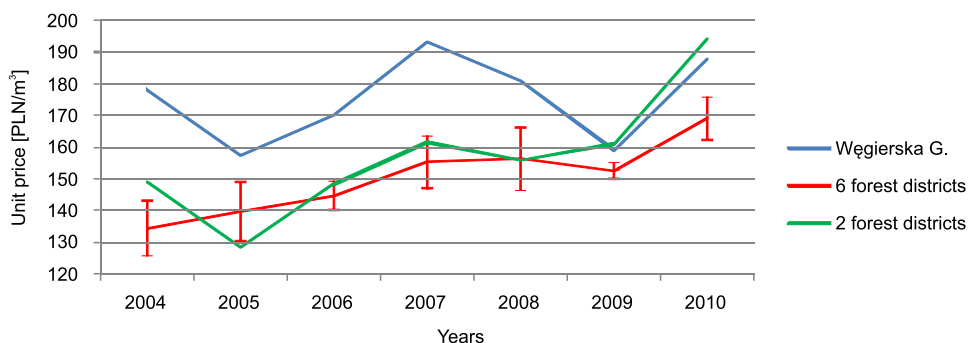
The unit prices of the large-diameter spruce timber of the D-quality grade (WD) in the Forest District of Węgierska Górka were from 6.52 PLN/m<sup>3</sup> (in 2009) to 43.70 PLN/m<sup>3</sup> (in 2004) or respectively 4.3% and 32.5% higher than prices calculated for the set of six forest districts. Moreover, the difference was significant as it was outside the confidence interval for the mean of the six forest districts (Fig. 3). The unit prices of the WD timber grade in the Forest District of Węgierska Górka were also higher than prices calculated for the set of two forest districts with the difference varying from 21.53 PLN/m<sup>3</sup> (in 2006) to 31.67 PLN/m<sup>3</sup> (in 2007) or respectively 17.4% and 24.4%. Only in the last two years the prices were somewhat lower

with 1.84 PLN/m<sup>3</sup> in 2009 (1.1%) and 6.43 PLN/m<sup>3</sup> in 2010 (3.3%). The analysis indicated a statistically significant ( $p < 0.01$ ) growing linear trend for the WD timber grade only between two sets of forest districts used as a comparison ( $p < 0.05$ , Fig. 3).

In 2004–2006, the unit prices of the medium-diameter timber of the S2a group in the Forest District of Węgierska Górka were above the upper limits of the confidence intervals used for the prices of the six forest district set. The prices were from 18.73 PLN/m<sup>3</sup> (in 2005) to 36.10 PLN/m<sup>3</sup> (in 2006) or respectively 17.6% and 33% higher. Comparing with the two forest district set, the prices were from 19.72 PLN/m<sup>3</sup> (in 2004) to 30.39 PLN/m<sup>3</sup> (in 2006), which are respectively 19.2% and 26.4% higher (Fig. 4). In subsequent years, the prices of the S2a timber grade in the Forest District of Węgierska Górka were fluctuating within the limits of confidence intervals established for the means of the six forest district set. At the same time, the prices of S2a timber grade were from 6.5 PLN/m<sup>3</sup> (in



**Figure 2.** Current unit prices of large-sized assortment of spruce grade C (PLN/m<sup>3</sup>) in the Forest District of Węgierska Górka and selected forest districts in the years 2004–2010 (note: figures 2 to 8 show a further average of the confidence intervals for the six forest districts and the average for the two forest districts)

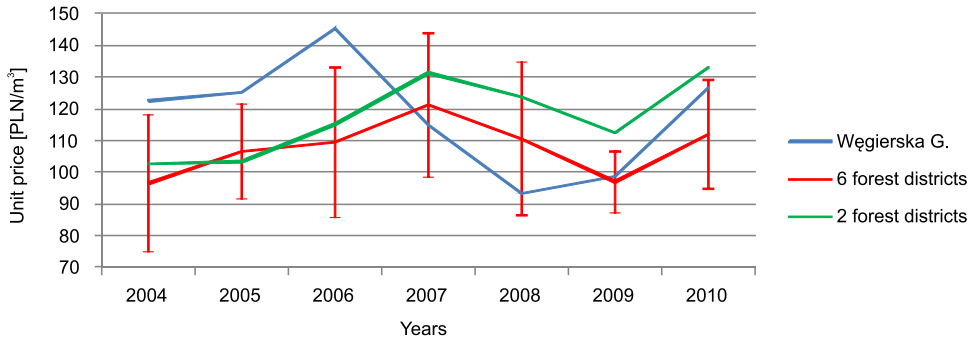


**Figure 3.** Current unit prices of large-sized assortment of spruce grade D (PLN/m<sup>3</sup>) in the Forest District of Węgierska Górka and selected forest districts in the years 2004–2010

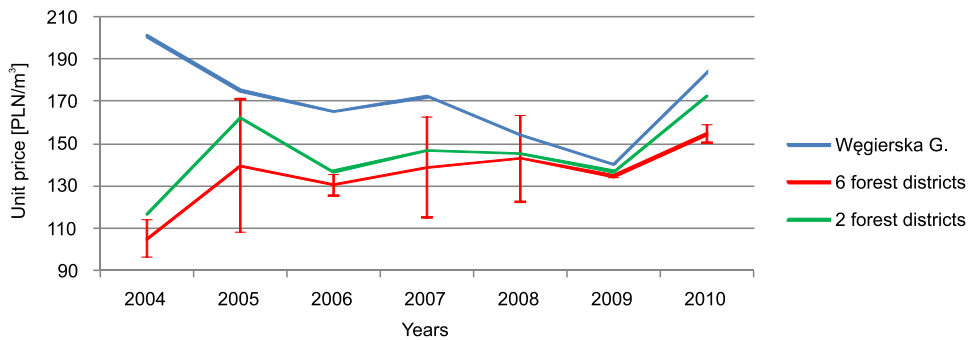
2010) to 30.35 PLN/m<sup>3</sup> (in 2008), or 4.9% and 24.6% lower than prices of that grade calculated for the set of two forest districts.

The linear trends of S2a timber grade prices were statistically significant ( $p > 0.05$ ) in any of the analysed sets of forest districts (Fig. 4).

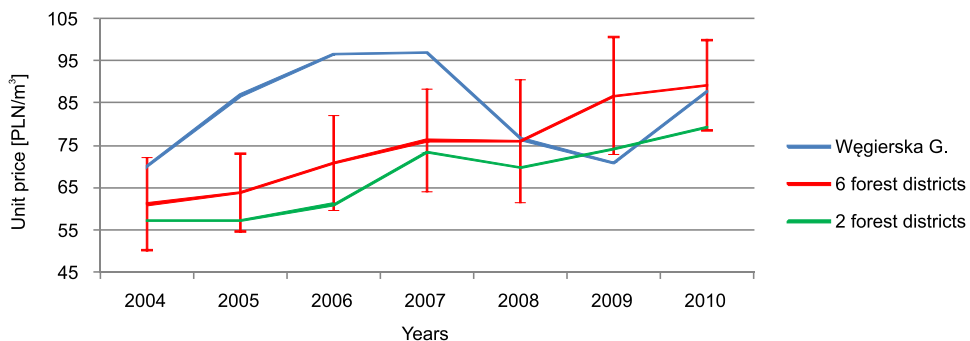
Unit prices of the medium-diameter S2b timber in the Forest District of Węgierska Górka were above the upper limits of the confidence intervals used for the prices of the six forest district set in all years besides 2008. Those prices were from 5.44 PLN/m<sup>3</sup> (2009) to 95.61 PLN/m<sup>3</sup> (2004), or respectively 4% and 90.9% higher than average



**Figure 4.** Current unit prices of medium-sized assortment of spruce grade S2a (PLN/m<sup>3</sup>) in the Forest District of Węgierska Górka and selected forest districts in the years 2004–2010



**Figure 5.** Current unit prices of medium-sized assortment of spruce grade S2b (PLN/m<sup>3</sup>) in the Forest District of Węgierska Górka and selected forest districts in the years 2004–2010



**Figure 6.** Current unit prices of medium-sized assortment of spruce grade S4 (PLN/m<sup>3</sup>) in the Forest District of Węgierska Górka and selected forest districts in the years 2004–2010

prices calculated for the set of six forest districts (Fig. 5). They were also from 3.38 PLN/m<sup>3</sup> (2009) to 84.07 PLN/m<sup>3</sup> (2004) or 2.5% and 72% higher than average prices in the set of two forest districts. In 2004–2009, the prices of the above timber grade in the Forest District of Węgierska Górka declined from 200.78 PLN/m<sup>3</sup> to 140.16 PLN/m<sup>3</sup> (the decline of 30.2%) and reached the level similar to that of prices in the comparative group of forest districts. Statistically significant ( $p < 0.05$ ) increasing linear trend for averages of S2b timber prices was found only for the set of six forest districts (Fig. 5).

The unit prices of the spruce middle-diameter timber grade S4 in the Forest District of Węgierska Górka were from 8.84 PLN/m<sup>3</sup> (2004) to 25.58 PLN/m<sup>3</sup> (2006), which are respectively 14.5% and 36.1% higher than prices of that grade calculated for the set of six forest districts (Fig. 6). They were also from 12.84 PLN/m<sup>3</sup> (2004) to 35.43 PLN/m<sup>3</sup> (2006) or 22.5% and 58% higher than prices for this timber grade in the set of two forest districts. There was also a drop in price in the Forest District of Węgierska Górka from 96.89 PLN/m<sup>3</sup> (2007) to 70.92 PLN/m<sup>3</sup> (2009), which equals to 25.97 PLN/m<sup>3</sup> (26.8%). In 2009, the S4 timber price in the Forest District of Węgierska Górka was 15.79 PLN/m<sup>3</sup> (18.2%) lower than average for the set of six forest districts and 3.18 PLN/m<sup>3</sup> (4.3%) than average for the set of two forest districts. The analysis showed that only linear growing trends calculated for the set of six and two forest districts are statistically significant (Fig. 6).

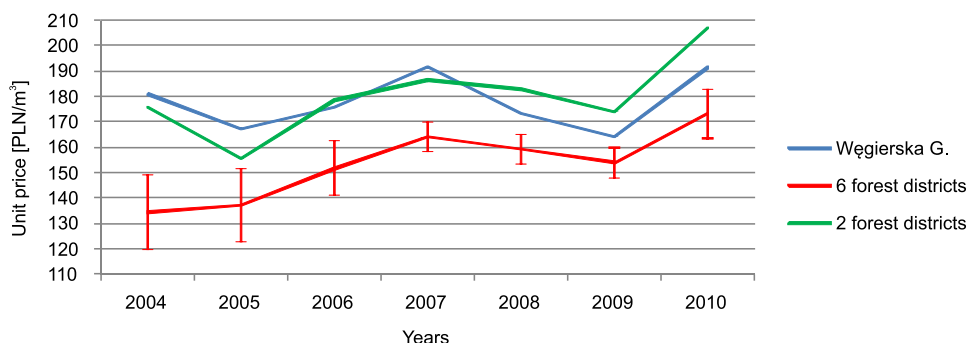
Unit prices of spruce timber (all grades) in the Forest District of Węgierska Górka were significantly higher than upper limits of the confidence intervals used for the means of the six forest district set (Fig. 7). They were from 10.28 PLN/m<sup>3</sup> (2009) to 46.54 PLN/m<sup>3</sup> (2004) or respectively 6.7% and 34.6% higher. Spruce timber prices

in the Forest District of Węgierska Górka were also somewhat higher from 5.13 PLN/m<sup>3</sup> (2007) to 11.75 PLN/m<sup>3</sup> (2005) or 2.8% and 7.6% than prices calculated for the set of two forest districts during the whole study period except 2006 when the price was 2.78 PLN/m<sup>3</sup> or 1.6% lower. After 2007, the analysed prices in the Forest District of Węgierska Górka were from 9.55 PLN/m<sup>3</sup> (2008) to 15.83 PLN/m<sup>3</sup> (2010) or respectively 5.2% and 7.6% lower than for the set of two forest districts. Unit spruce timber prices in the Forest District of Węgierska Górka and in the set of two forest districts went through substantial fluctuations, and therefore a statistically significant ( $p < 0.05$ ) linear growing trend could be shown only for the set of six forest districts (Fig. 7).

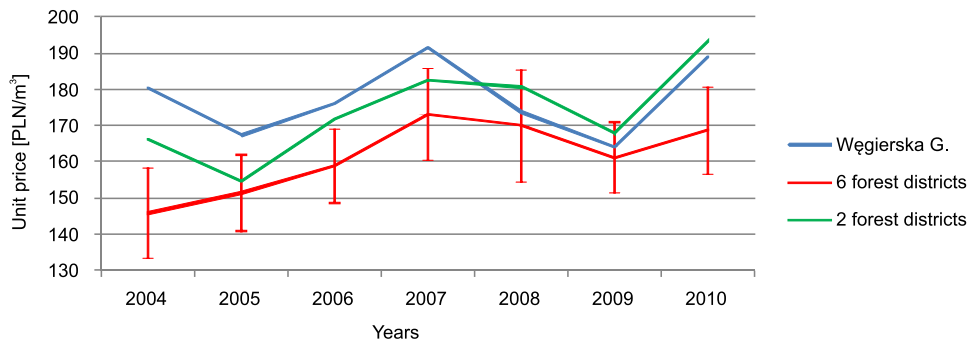
The overall timber prices in the Forest District of Węgierska Górka were from 2.94 PLN/m<sup>3</sup> (2009) to 35.12 PLN/m<sup>3</sup> (2004), which are 1.8% and 19.4% higher than prices calculated for the set of six forest districts (Fig. 8); however in 2008–2009 they did not go outside the established level of significance interval for means in that group. In 2004–2007, timber prices in the Forest District of Węgierska Górka were from 4.06 PLN/m<sup>3</sup> (2006) to 14.55 PLN/m<sup>3</sup> (2004) or respectively 2.3% and 8.7% higher than prices obtained for the set of two forest districts, whereas in the following years, the prices were from 2.16 PLN/m<sup>3</sup> (2010) to 7.42 PLN/m<sup>3</sup> (2008) or respectively 1.1% and 4.1% lower. The linear growing trend was found to be statistically significant ( $p < 0.05$ ) only for the set of six forest districts (Fig. 8).

## 5. Discussion and conclusions

The decline of large-diameter timber prices on 8.1% (WC) and 11.7% (WD) was noted in 2005 in the Forest District of Węgierska Górka after the hurricane that oc-



**Figure 7.** Current unit prices of timber spruce (PLN/m<sup>3</sup>) in the Forest District of Węgierska Górka and selected forest districts in the years 2004–2010



**Figure 8.** Overall timber prices (PLN/m<sup>3</sup>) in the Forest District of Węgierska Górka and compared forest districts in 2004–2010

occurred in the end of 2004. Subsequent apparent decreases in prices occurred in 2008 as a result of excessive supply of timber (Table 3). However, such excessive supply was not observed in the preceding year, though the sale level was similar as in 2008, which is above 180,000 m<sup>3</sup> of timber. Such a situation resulted from the macroeconomic conditions of timber market and the deficit of about 2 million m<sup>3</sup> of timber at the national level in 2007 (Ślęzak 2012). Growth of unit prices with the simultaneous growth in timber supply was also observed by Adamowicz and Dyrzc (2008). Large declines in prices in 2005 in the Forest District of Węgierska Górka mainly resulted from unwillingness to buy timber after the hurricane, and even more in the conditions of decreased demand on timber products. The opposite situation was noted in 2007 when in similar circumstances timber market prices did not decline despite identically large hurricane damages. The decrease in prices in the Forest District of Węgierska Górka and in the studied sets of forest districts in 2009 was the consequence of the global crisis. Similar opinions were expressed by Adamowicz (2012), Lis (2009, 2012) and Ratajczak (2011). Analysed periodic fluctuations and mainly declines of prices were lower than those presented by Kaliszewski (2009) or 15% for the large-diameter timber of C-grade after the hurricane in the Puszcza Piska forest. Prestemon and Holmes (1998) noted 35% decrease in prices of pine sawmill timber after the hurricane Hugo, while Svensson et al. (2011) estimated sawmill timber price decrease at about 29%.

The prices of medium-diameter grades in the Forest District of Węgierska Górka were developing differently. After the hurricane, there was a notable decline of 12.7% only in prices of S2b timber grade in 2005 (Table 3). In spite of larger timber sales increasing from about 8000 m<sup>3</sup> in 2004 to about 60,000 m<sup>3</sup> in 2008, the prices of S2b timber grade in the Węgierska Górka Forest District re-

mained high compared with the prices in two analysed sets of forest districts. Significant price decline of 10.6% resulting from excessive supply was noted only in 2008.

The price of S2a timber grade decreased at 21.1% in 2007 even though sales of this grade were lower (3000 m<sup>3</sup>) than in the preceding year. However, in the next year, the growth in sales of this grade at more than 4000 m<sup>3</sup> resulted in the drop of its prices. There was even a slight increase in prices of S2a timber grade at 6.1% regardless of the above mentioned crisis in 2009. According to Lis (2009), such a situation is usual, as decreases in prices do not cover all timber grades in the same period.

Apparent price decline at 21% was observed for the S4 timber grade in the Forest District of Węgierska Górka only in 2008 when sale level was similar to the preceding year or about 6000 m<sup>3</sup>. Hence, medium-diameter timber prices, and especially price declines, were significantly lower than those given by Kaliszewski (2009) or 50% for the S2a timber grade after the hurricane in Puszcza Piska forest. After the hurricane Hugo, Prestemon and Holmes (1998) registered a price drop of pine peeler timber at 60%. According to Svensson et al. (2011), peeler prices in Sweden dropped 36% after the Gudrun hurricane.

The share of WC timber was 46.6% in 2004 and 30.8% in 2008. The situation for WD timber was different with 20% in 2004 and 32.6% in 2008. The increased share of lower quality timber had a large influence on the development of average spruce timber prices and prices in general. It resulted in significantly greater price decreases in the Forest District of Węgierska Górka than in analysed sets of forest districts in 2008 (Table 3). However, price drops were lower than those presented by Baur et al. (2003) after the hurricane Lothar at about 30%. Svensson et al. (2011) present decreases in timber prices at about 33% after the Gudrun hurricane. Holmes (1991) men-



**Table 3.** The increase (decrease) rate of unit prices of selected assortments of timber and average prices of timber spruce as well as average prices of total timber in the Forest District of Węgierska Górka and selected forest districts in the years 2004–2010

Wyszczególnienie	Years						
	2004	2005	2006	2007	2008	2009	2010
Large-sized assortment of spruce grade C <sup>1</sup>							
Węgierska Górka	-	-8.10	6.23	9.56	-3.62	-1.72	16.30
6 nadleśnictw	-	-0.64	3.69	5.75	2.93	-13.24	11.45
2 nadleśnictwa	-	-14.97	24.47	4.16	2.85	-10.35	18.54
Large-sized assortment of spruce grade D <sup>2</sup>							
Węgierska Górka	-	-11.69	7.99	13.74	-6.46	-12.00	18.03
6 nadleśnictw	-	3.87	3.64	7.31	0.62	-2.39	10.79
2 nadleśnictwa	-	-13.95	15.62	8.90	-3.53	3.23	20.68
Medium-sized assortment of spruce grade S2a <sup>3</sup>							
Węgierska Górka	-	2.29	16.11	-21.13	-18.74	6.05	27.98
6 nadleśnictw	-	10.53	2.64	10.77	-8.73	-12.37	15.51
2 nadleśnictwa	-	0.52	11.41	14.13	-5.93	-9.00	18.30
Medium-sized assortment of spruce grade S2b <sup>4</sup>							
Węgierska Górka	-	-12.73	-5.72	4.27	-10.64	-8.95	31.16
6 nadleśnictw	-	32.84	-6.64	6.45	3.03	-5.81	14.78
2 nadleśnictwa	-	38.99	-15.70	7.55	-1.19	-5.87	26.18
Medium-sized assortment of spruce grade S4 <sup>5</sup>							
Węgierska Górka	-	24.09	11.14	0.42	-21.00	-7.34	23.83
6 nadleśnictw	-	4.40	11.11	7.38	-0.10	14.02	2.96
2 nadleśnictwa	-	0.02	6.86	20.07	-4.97	6.37	7.04
Average prices of timber spruce							
Węgierska Górka	-	-7.52	5.05	8.97	-9.54	-5.26	16.59
6 nadleśnictw	-	2.01	10.61	8.22	-2.98	-3.36	12.51
2 nadleśnictwa	-	-11.45	14.77	4.40	-1.93	-4.86	19.14
Overall timber prices							
Węgierska Górka	-	-7.52	5.05	8.97	-9.54	-5.26	16.59
6 nadleśnictw	-	3.82	4.96	8.95	-1.79	-5.19	4.64
2 nadleśnictwa	-	-6.98	10.94	6.34	-1.05	-7.13	15.34

<sup>1</sup> including logs and special timber in various classes of thicknesses

<sup>2</sup> including logs in various classes of thicknesses

<sup>3</sup> including pulp-wood in various classes of length

<sup>4</sup> including pulp-wood in various classes of length

<sup>5</sup> including large dimension of fire-wood

Source: Own study based on reports from SFIS database

tions price drops at about 25% as a consequence of insect outbreak in the USA while Prestemon and Holmes (2000) present price decreases after the hurricane at about 30%.

As Baur et al. (2003) indicate, it is difficult to analyse unit prices through longer time periods as numerous macroeconomic and microeconomic factors influence them. Raw timber prices are affected by the characteristics of supply and demand. With stable supply and increasing demand, prices start to increase, while with stable demand and growing supply, prices decline (among others Holmes 1991; Prestemon and Holmes 2004; Hyde 2008; Prestemon and Holmes 2010). As shown by Ratajczak (2011), social need in finished wood products is a main formative factor in the process of demand shaping. Noted price hikes for raw timber that occurred despite increased timber sales were largely dependent on macroeconomic timber market conditions, and specifically on steady international demand, growing construction sector and activities in other sectors, such as energy sector. Ratajczak and Sława-Neyman (1997) state that negative economic consequences of the hurricane that occurred in the beginning of the 90<sup>th</sup> in Germany were lower due to favourable economic situation resulting from high demand on timber in the construction sector. According to Piszczek and Janusz (2012), the growth in prices of some timber grades and slower decrease in prices could be caused by the situation in energy sector and higher demand on timber of lower quality and medium-size timber grades. A similar opinion was expressed by Ratajczak (2011) who shows that energy sector became a competitor especially for the production of wood composite boards, paper production, production of wood pallets and small wooden architecture. However, it is evident that excessive supply of timber caused by natural disasters in the conditions of low demand would result in noticeable price declines.

The costs of transportation and units related to that process play an important role in development of raw timber prices. Excessively high transportation costs would make long-distance transportation to be unprofitable according to Hyde (2008). He also noted that profitability could still increase with higher quality timber grades. As suggested by Prestemon et al. (2001), profitability of transportation costs can undoubtedly result in a situation when some part of excessive timber supply is absorbed by external market outside the area affected by natural disaster. This could explain increasing or lasting high prices of large-diameter timber grades and decrease in prices on timber of lower quality such as S2a and S4. Microeconomic elements also affect development of raw timber prices, and

especially marketing activities implemented by the State Forests National Forest Holding. The dominant position of the State Forests at the timber market could allow some regulation of timber sales in the aftermath of natural disasters, which would permit some mitigation of price drops in the regions affected by natural disaster.

The results of the above research allow us to formulate the following conclusions:

- increased supply of raw timber as a result of natural disaster in forests causes clear price decline of only some timber grades, mainly of large-diameter sawmill timber,
- declines of medium-diameter spruce timber prices and of timber in general were mainly caused by its lower quality,
- macroeconomic elements have a crucial effect on development of raw timber prices in conditions of natural disasters in forests, which include demand on finished wood products, as well as negotiating abilities of timber buyers,
- natural disasters cause economic losses in forest economy, which result from lower profits from raw timber sales characterised by clear periodic fluctuations,
- marketing activity of the State Forests is of significant importance in mitigation of effects caused by excessive supply of raw timber in the aftermath of natural disasters.

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## **Contributions**

A.T.S. – an author of the article conception, literature review, study data collecting, study data interpretation, manuscript preparation; J.U. – support in statistical analysis and statistical consultation