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Analysis of acquisition and potential usage of conifer cones from Polish seed extraction houses between 2009–2012

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Abstract. *Analysis of acquisition and potential usage of conifer cones from Polish seed extraction houses between 2009–2012*. The paper presents data on acquisition of conifer cones from 16 seed extraction plants operating on the territory of Poland during four consecutive years from 2009 to 2012. A high variability was observed in provision of seed units to the seed exaction plants related to specificity of a given seed year. During the four analyzed years the most commonly acquired cone was that of Scots pine – above 1.3 thousand Mg, and the most rare were pines of common fir – 31 Mg. The plants that process the largest number of cones are seed extraction plants in forest districts of Jarocin, Kluczbork and Rytel where over 600 Mg of cones were extracted. Conifer cones, which are usually treated as waste, may be utilized as an energy source. After seed extraction their mass decreases from 16 to 30% depending on the species. The analysis showed that the annual quantity of conifer cones that can be used as an energy source is on average 270 Mg of empty cones.

Key words: seed, extraction, plants, extraction waste, conifer cones, combustion

INTRODUCTION

Every year in Poland collected are seeds of both deciduous and coniferous tree species. Seeds of most coniferous trees are stored in cones and acquiring them requires thermal or mechanical processing. The seeds are obtained from the cones in specialized seed extraction plants. These are business units where conifer cones are stored, cleaned, extracted in special chambers or cabinets and, eventually, sold or incinerated. The seed extraction plants also clean, separate and store the seeds itself. In the past, the seed extraction plants have only dealt with seeds of coniferous trees, but today such establishments also deal with processing and preparation of deciduous seeds for storage and sowing, the beech seed stratification or hot water treatment for oak seeds [Suszka et al. 2000].

The number of seed extraction plants operating in Poland has been changing during the last 50 years. During the 1970s there were 32 seed extraction plants. In most cases these were of old type, operating according to the original XIX c. German technologies [Załęski 1995]. In the 1980s the number shrunk to 26 and in the 1990s to 22. At present there are 16 seed extraction plants and almost every other one is based on modern Swedish technology.

During the seed extraction process, the cones are held stationary in special boxes placed in chambers or cabinets and exposed to dry (low humidity) air of increased temperature (to 50–55°C) that has no negative impact on the seeds [Tyszkiewicz 1949]. The number of extracted cones in the seed extraction plants is related to the seed years. The paper presents data on the quantity of cones

obtained from four coniferous species (Scots pine, common spruce, European (Polish) larch and the silver fir) between 2009–2012 in individual seed extraction plants. The collected data allows for estimation of the average quantity (in megagrams) of empty cones available in the extraction plants.

Empty cones are treated as waste in most extraction plants. Only in 20% of such businesses they are used solely as fuel in the process of extraction of full cones. In the remaining companies the cones are treated as a product sold to tree nurseries as substrate component or as an decorative element used in production of floral and festive decorations. A novel idea is to utilize the empty cones as fuel for production of pellets or briquettes similar to wood-chips [Gendek and Zychowicz 2014]. Studies realized by Aniszewska and Gendek [2014] allowed for drawing a conclusion that empty cones are a material characterized by high heat of combustion and calorific value.

However in order for production of pellets or briquettes to be possible and profitable, it is necessary to know the average annual quantity of empty cones that can be obtained for such purposes.

MATERIAL AND METHODS

The data on the quantity of conifer cones collected in the extraction plants of the four species: Scots Pine, common spruce, European larch (Polish – not differentiated in the study) and the silver fir, was gathered via direct phone and e-mail contact with plant's managers responsible for acquisition of seed material in the Regional Directorates of State Forests (RDLP) [Kuszpit 2014]. The data was collected from all extraction plants operating on the territory of Poland between 2009–2012.

RESULTS AND DISCUSSION

The process of extracting seeds from conifer cones and subsequent processing of seeds is realized every year in 16 seed extraction plants. However, not all extraction plants acquire seeds from the four species indicated above. Figure 1 presents which seeds are acquired in individual seed extraction plants [Fonder et al. 2007]. In the six plants located in the forest districts of: Rytel, Jedwabno, Maskulińskie, Czarna Białostocka, Łochów, Kaliska, between 2009–2012 the extracted cones were of: Scots pine, common spruce and larch. In two out of sixteen plants located in forest districts of: Białogard and Nowa Sól – cones of Scots pine and larch, and in the remaining eight: all four species. For example, silver fir pines were acquired in the central and southern part of Poland and the common spruce was not processed in the western part of the country as there are no natural maternal forests in that area, which would consist of the best specimen. In total, during the four years extracted were: 1306 Mg of scots pine cones, 58 Mg common spruce cones, 36 Mg of larch cones and 31 Mg of silver fir cones.

Among the 15 seed plants (this analysis lacks the extraction plant in the Forest District of Grotniki) the largest number of cones processed was observed in Lasowice Seed Extraction Plant in Forest District Kluczbork – 208 Mg, Jarocin – 207 Mg and Rytel nearly 199 Mg and the low-

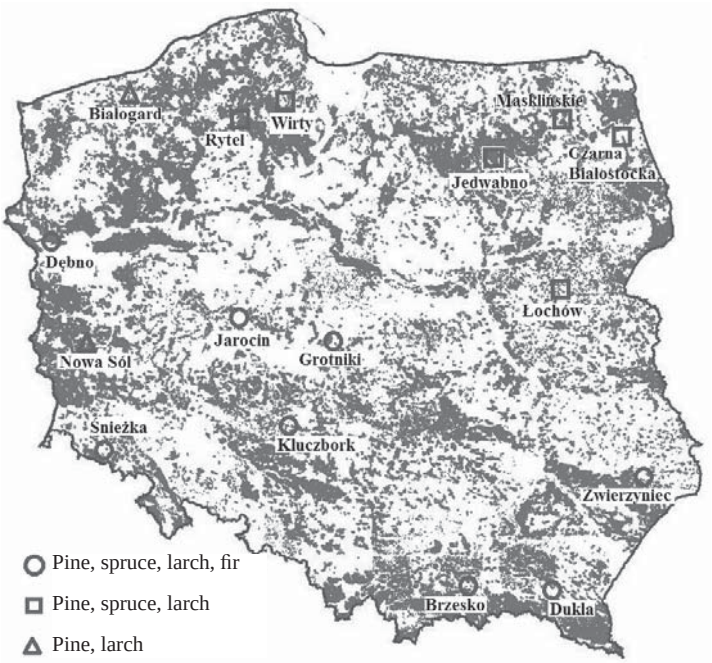

FIGURE 1. Map of Poland with indicated locations of seed extraction plants

est number in the Brzesko Forest District seed extraction plant – 11.8 Mg (Fig. 2).

Table 1 presents data on the quantity of cones from four coniferous species: Scots pine, common spruce, European larch and silver fir in individual seed extraction plants. The Scots pines provided the largest quantity of cones. In the listed extraction plants the largest number of Scots pine cones were processed in 2010 in the following forest districts: Jarocin – 120 thousand kg, Nowa Sól – 97.5 thousand kg, Rytel – 80 thousand kg, and Dębno – 75.8 thousand kg. The lowest

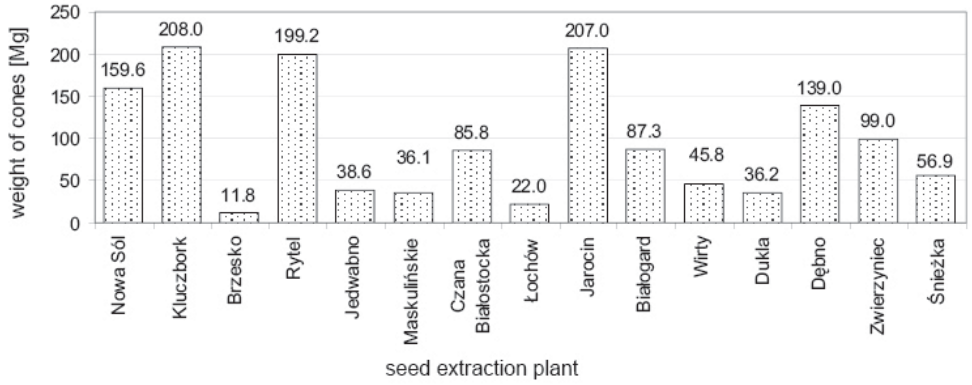

FIGURE 2. The total weight of cones extracted in the seed extraction plants between 2009–2012

TABLE 1. Weight of cones provided to extraction plants between 2009–2012 [Kuszpit 2014]

RDLP	Forest district	Year	Conifer cones obtained [kg]			
			pine	spruce	larch	fir
1	2	3	4	5	6	7
Zielona Góra	Nowa Sól	2009	4,616	0	0	0
		2010	97,508	0	2,365	0
		2011	32,251	0	0	0
		2012	22,839	0	0	0
Katowice	Kluczbork	2009	51,876	675	1,253	2,445
		2010	48,601	120	2,218	0
		2011	38,341	118	613	759
		2012	54,337	725	3,429	2,472
Kraków	Brzesko	2009	3,058	165	242	80
		2010	3,576	300	645	0
		2011	1,669	0	0	0
		2012	2,058	0	12	0
Toruń	Rytel	2009	47,218	505	936	0
		2010	80,164	240	1,339	0
		2011	33,488	300	194	0
		2012	34,027.4	394.2	359.4	0
Olsztyn	Jedwabno	2009	2,790	1,080	25	0
		2010	15,128	500	4,210	0
		2011	7,768	0	0	0
		2012	6,881	250	0	0
Białystok	Maskulińskie	2009	1,804	520	0	0
		2010	10,643	0	0	0
		2011	11,794	0	110	0
		2012	8,856	2,370	0	0
Białystok	Czarna Białostocka	2009	5,807	440	0	0
		2010	20,327	0	2,564	0
		2011	15,410	4,705	0	0
		2012	13,253	22,090	1,232	0
Warszawa	Łochów	2009	895	2,675	0	0
		2010	5,819	0	0	0
		2011	3,267	0	0	0
		2012	8,448	111	800	0

TABLE 1 cont.

1	2	3	4	5	6	7
Poznań	Jarocin	2009	7,110	250	105	1,833
		2010	120,490	1,533	1,385	740
		2011	42,328	0	0	0
		2012	29,144	555	458	1,050
Szczecinek	Białogard	2009	7,259.5	0	732.4	0
		2010	12,300.3	0	503.56	0
		2011	30,088.7	0	0	0
		2012	36,197.95	0	190	0
Gdańsk	Kaliska (Forest region Wirty)	2009	2,670	0	1,154.5	0
		2010	21,716.4	578	0	0
		2011	12,437	0	0	0
		2012	6,100.7	1,100	0	0
Krosno	Dukla	2009	3,791	742	844	1,116
		2010	4,426	100	689	1,181
		2011	9,064	0	420	123
		2012	8,274	1,100	419	3,926
Szczecin	Dębno	2009	9,204	465	0	70
		2010	75,872.35	950	1,980	0
		2011	25,375.6	0	0	0
		2012	21,967.55	3,150	0	0
Lublin	Zwierzyniec	2009	8,058	252	610	1,141.6
		2010	14,563.95	0	1,093	1,405
		2011	31,724.67	2,415	348	6,255
		2012	28,409.95	1,894	766	95
Wrocław	Śnieżka	2009	3,007.6	1498,8	1,166.5	6,103
		2010	25,583.6	2871,4	821.1	0
		2011	6,892.6	168	30.9	275
		2012	7,438.6	533,2	184.9	331.2

processed quantities were observed in forest districts of Brzesko, Łochów and Dula – about 3 thousand kg.

The largest utilization of common spruce was realized in Czarna Białostocka forest district in 2012 – 22 thousand kg. In the remaining extraction plants the quantity did not exceed 3 thousand kg.

In 2012 the extraction of larch and pine cones was the largest observed, in forest districts: Jedwabno – 4.2 thousand kg, and about 2.3 thousand kg in Czarna Białostocka, Kluczbork, Nowa Sól and Dębno. The extraction plant in

Kluczbork is an interesting case here as in 2012 it processed over 3.4 thousand kg and in 2011 only 0.6 thousand kg.

Common fir is collected in only eight extraction plants. The largest number of seeds is obtained in extraction plants in forest districts of Zwierzyniec and Śnieżka – about 6.0 thousand kg each. In 2012 in Dukla forest district – about 4.0 thousand kg, in Kluczbork – 2.4 thousand kg.

Data analysis shows the seed years for a given species. The largest number of Scots pine cones was obtained in 2010 – 555 Mg, common spruce cones in 2012 – 34 Mg, larch in 2010 – 20 Mg, common fir in 2009 – nearly 13 Mg (Fig. 3).

The analysis of basic statistical parameters of cones delivered to extraction plants from 2009 to 2012 is presented in Table 2, and the average value according

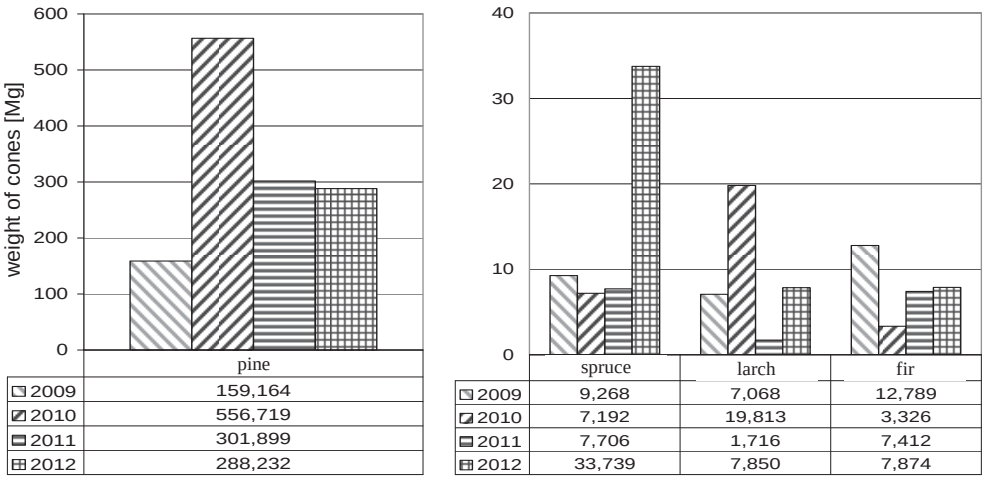

FIGURE 3. Total weight of cones provided to extraction plants between 2009–2012

TABLE 2. Averages, standard deviation – SD coefficient of variation – CV and standard errors – SE of the cones delivered to the extraction plants for the four species in kg in individual years

Species	Year	Average	SD	CV	SE
Pine	2009	10,610.94	16,016.60	150.9442	4,135.469
Spruce	2009	617.85	703.92	113.9292	181.750
Larch	2009	471.23	500.00	106.1051	129.098
Fir	2009	852.57	1,652.73	193.8521	426.733
Pine	2010	37,114.57	38,003.10	102.3940	9,812.358
Spruce	2010	479.49	793.05	165.3925	204.764
Larch	2010	1,320.84	1,173.71	88.8604	303.050
Fir	2010	221.73	476.51	214.9035	123.035
Pine	2011	20,126.57	13,725.62	68.1965	3,543.940
Spruce	2011	513.73	1,313.19	255.6171	339.064

TABLE 2 cont.

1	2	3	4	5	6
Larch	2011	114.39	194.14	169.7145	50.127
Fir	2011	494.13	1,606.45	325.1037	414.782
Pine	2012	19,215.48	14,834.50	77.2008	3,830.250
Spruce	2012	2,284.83	5,558.50	243.2787	1,435.198
Larch	2012	523.35	885.56	169.2091	228.651
Fir	2012	524.95	1,153.01	219.6426	297.705

to the four analyzed species is given in Table 3.

When considering utilization of empty cones in production of pellets or briquettes, we need to assess the average number of cones that can be obtained from individual seed extraction plants. Figure 4 presents the average weight of full cones in Mg. The three cone extraction plants in forest districts of Kluczbork, Rytel and Jarocin was obtained about 50 Mg of full cones, and in the remaining ones somewhat less. Until this point the author has utilized the weight

TABLE 3. Averages, standard deviation – SD, coefficient of variation – CV and standard errors – SE of the cones delivered to the extraction plants for the four species in kg in all extraction plants in the four analyzed years

Species	Average	SD	CV	SE
Pine	21,766.89	24,379.49	112.0026	3,147.379
Spruce	973.98	2931.31	300.9634	378.431
Larch	607.45	882.58	145.2916	113.941
Fir	523.35	1,296.44	247.7212	167.370

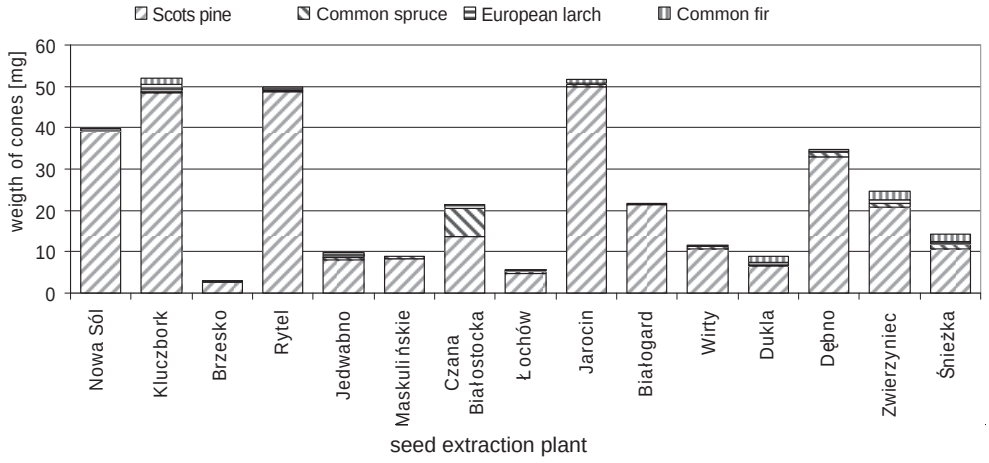

FIGURE 4. Average weight of cones provided to seed extraction plants between 2009–2012

of full cones delivered to the extraction plants. From this value deducted should be the weight of the seeds themselves (about 1–2% of total weight of a cone) and the weight of water that is lost during the extraction process. On average the pine cones have about 0.35 kg water per kg of dry weight, and decrease their weight after the extraction process by about 30%. The spruce cones lose about 20%, and larch cones (with water content of 0.20 kg water per kg of dry weight) by about 16% [Aniszewska 2008, 2012].

Therefore it is possible to calculate the actual weight available for combustion by decreasing the weight of full cones by about 22% (average). For example, if the weight of full cones in extraction plant in Kluczbork forest district is 53 Mg (Fig. 4) then after extraction there will remain about 40 Mg of cones that can be utilized for energy purposes. The analysis of the total average weight of cones obtained during the last four years shows that annually about 270 Mg of cones are available for energy purposes.

It is worth mentioning, that after the extraction process apart the loss of weight, the cones also increase their volume: larch – one-fold. pine – two-folds. fir – three-folds. The increased volume of cones is a significant problem when transporting the cones to the local power plants.

SUMMARY AND CONCLUSIONS

- Utilization of cones obtained from the 16 seed extraction plants in Poland for energy purposes is related to the number of cones available in a given year and is, in many cases, difficult to forecast.
- Not all extraction plants process the same number of cones each year, which may result in problems with providing the planned amount of cones to the power plants.
- Three extraction plants (out of 16) utilize cones as energy source to heat the extraction cabinets. These are extraction plants with large extraction chambers. Between 2009–2012 these plants were responsible for extracting nearly 600 Mg of cones, which is about one-thirds of the total material available for production of pellets or briquettes.
- The Polish seed extraction plants are able to provide about 270 Mg of empty cones annually for energy purposes (based on the four-year analysis).
- Due to low weight of the empty cones and their large volume the profitability of long-range transport may be problematic. Therefore they should be used as energy fuel only on the local market, however, drawing such a conclusion requires further studies.

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Streszczenie: *Analiza pozyskania i możliwość wykorzystania na cele energetyczne szyszek gatunków drzew iglastych z polskich wyłuszczarni w latach 2009–2012.* W artykule przedstawiono dane liczbowe dotyczące pozyskania szyszek czterech gatunków drzew: sosny zwyczajnej, świerka pospolitego, modrzewia europejskiego i jodły zwyczajnej, z 16 wyłuszczarni pracujących na terenie Polski w ciągu lat 2009–2012. Otwarte szyszki pozbawione nasion i traktowane jako odpad połuszczarski mogą być wykorzystane na cele energetyczne w lokalnych elektrowniach. Aby w tym celu można było je wykorzystać, należy na początek sprawdzić, ile rocznie pozyskuje się tego materiału. Zauważono dużą zmienność w dostarczaniu jednostek nasiennych do wyłuszczarni związaną z latami nasiennymi. Przez cztery analizowane lata najwięcej pozyskano szyszek sosny zwyczajnej ponad 1,3 tys. Mg, a najmniej jodły pospolitej – 31 Mg. Ze względu na stosunkowo małą masę pojedynczych szyszek i dużą objętość szyszki można transportować na niewielkie odległości. Do wyłuszczarni łuszczących najwięcej szyszek należą obiekty w Nadleśnictwach Jarocin, Kluczborki i Rytel, gdzie dostarczano łącznie 600 Mg szyszek rocznie. Po łuszczeniu szyszki zmniejszają swoją masę w zależności od gatunku od 16 do 30%. Analiza wykazała, że rocznie można wykorzystać na cele energetyczne średnio 270 Mg pustych szyszek. Szyszki traktowane jako odpad mogą być bezpośrednio spalane lub wykorzystane jako dodatek w produkcji brykietów i peletów.

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