Regular Article
pISSN: 2288-9744, eISSN: 2288-9752
Journal of Forest and Environmental Science
Vol. 33, No. 3, pp. 233-238, August, 2017
https://doi.org/10.7747/JFES.2017.33.3.233

JFES
Journal of Forest and Environmental Science

Log Production of Major Commercial Species for Sawtimber in Hongcheon Region of South Korea

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Abstract

This study was carried out to figure out the number of logs for sawtimber by DBH and height class and to compare merchantable volume ratio by categorizing into sawtimber, lagging board and pulpwood, and others for *Pinus densiflora*, *Pinus koraiensis*, and *Larix kaempferi*. Logs for sawtimber were hardly produced in small DBH class of three species, but produced evidently from medium DBH class. In large DBH class, the number of logs for sawtimber were noticeably different among species: 4.3 logs for *L. kaempferi*, 2.6 logs for *P. densiflora*, and 1.0 logs for *P. koraiensis* on average. Similarly, merchantable volume ratio for sawtimber were largely different among species in large DBH class with higher than 15 m: 82% logs for *L. kaempferi*, 60% logs for *P. densiflora*, and 44% logs for *P. koraiensis*. When compared to the upper diameter and upper height by species with regard to the last log of a tree produced for sawtimber, upper diameter was smallest with 14.1 cm and upper height was highest with 12.2 m in *L. kaempferi*. Overall, *L. kaempferi* was considered as the more commercial species for sawtimber production than *P. densiflora* and *P. koraiensis*.

Key Words: merchantable volume ratio, upper diameter, upper height, lagging board, pulpwood

Introduction

Log is defined as a thick, round, and tall tree trunk, not sawed into timber board (Korea Forest Service 2017). It is important for foresters to produce high-grade logs because the log price is different by log grade. High-grade logs are used as building materials such as structural material, molding, deck, laminated timber, and treated wood, which are termed sawtimber. Other low-grade logs were treated as lagging board and pulpwood (National Forestry Cooperative Federation 2017). Thus, maximizing the log production for sawtimber is economical to forestry, and so many foresters have been interested in this topic.

In the advanced forestry countries, the researches about log production have been conducted by species and grade, and tried to find out the best economical felling based on the log length by use (Deadman and Goulding 1979; Perstorper et al. 1995; Pickens et al. 1997; Mousavi 2009). In addition, stem quality of major timber species has been studied because the stem quality is directly related to the log

Received: August 10, 2017. Revised: August 17, 2017. Accepted: August 22, 2017.

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production (Choi et al. 2008). In Korea, studies on log diameter classes and log grading for major species were studied in some researches (Shim and Yeo 2004; Kwon et al. 2007; Park et al. 2013), but it is still insufficient, especially for sawtimber.

In Korea, logs are produced by species group according to the characteristics and grade such as diameter, length, knot, ring shake, crook, decay, and etc. The log length decisively differentiate usage of wood among those characteristics. The length is mainly categorized as 1.8 m, 2.7 m, and 3.6 m by major timber species (Korea Forest Research Institute 2013).

As the major timber species of Korea, *Pinus densiflora*, *Pinus koraiensis*, and *Larix kaempferi* are mainly used for domestic timber (Korea Forest Research Institute 2012a, 2012b, 2012c) and accounted for 21.5%, 5.6%, and 65.3%, respectively, in terms of the volume production for sawtimber during July 2015 to June 2016 (Kim 2017). Also, each species are covered in most of coniferous forest area of Korea: 1,562,843 ha (66.8%) for *P. densiflora*, 170,905 ha (7.3%) for *P. koraiensis*, and 272,800 ha (11.7%) for *L. kaempferi* in the present (Korea Forest Service 2016). At this point, timber management is necessary for these species.

Therefore, the purpose of this study was to figure out the number of logs for sawtimber and compare the merchantable volume ratio targeting on *P. densiflora*, *P. koraiensis*, and *L. kaempferi*.

Materials and Methods

Study area

The study area of this research was *P. densiflora*, *P. koraiensis*, and *L. kaempferi* stands of national forest supervised by Hongcheon National Forest Management Office, which managed the largest national forest area, 118,527 ha, among National Forest Management Offices in Korea (Korea Forest Service 2016). The selected sites were in the forest stands for logging, located in Hongcheon and Hoengseong, Gangwon province, and investigated during July to September 2011 (Fig. 1). Annual precipitation ranged from 704 mm to 1637 mm and annual mean temperature from 10.6°C to 12.2°C for the last ten years (Hongcheon-gun 2016).

The total number of forest stands were 14 sites for this study: 4 sites for *P. densiflora*, 2 sites for *P. koraiensis*, and 8 sites for *L. kaempferi*. From the sites the number of collected samples were 55 trees for *P. densiflora*, 56 trees for *P. koraiensis*, and 187 trees for *L. kaempferi*, and a variety of sample sizes were measured in terms of DBH, height, and volume (Table 1).

Data collection and analysis

In study area, the site and stand information were collected such as site location, slope, aspect, topography, and forest type. Then, the information of each sample trees was collected in field procedures. First, after a tree was felled, the sample tree was cut in accordance with log length: 1.8 m, 2.7 m, and 3.6 m (Korea Forest Research Institute 2013). Sample trees were especially cut to maximize the number of 3.6 m logs from the stem base by priority, and then 2.7 m logs were produced when 3.6 m logs cannot be produced

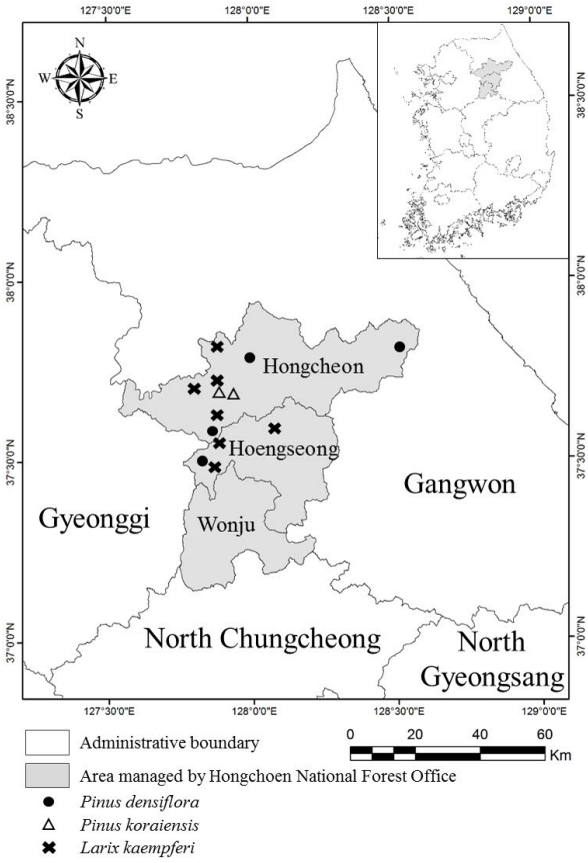

Fig. 1. Study locations where logs were collected.

Table 1. Statistics summary of sample trees by species

Species	Statistics	DBH (cm)	Height (m)	Volume (m^3)	No. of trees
Pinus densiflora	Mean	27.3	17.5	0.5145	55
	SD	7.2	4.9	0.2986	
	Minimum	12.0	5.5	0.0428	
	Maximum	42.0	25.3	1.2753	
Pinus koraiensis	Mean	17.3	14.9	0.2091	56
	SD	5.1	2.5	0.1424	
	Minimum	6.0	7.3	0.0127	
	Maximum	36.8	19.9	0.9201	
Larix kaempferi	Mean	22.6	21.6	0.4607	187
	SD	5.5	3.8	0.2708	
	Minimum	11.2	12.0	0.0528	
	Maximum	44.2	30.3	1.5569	

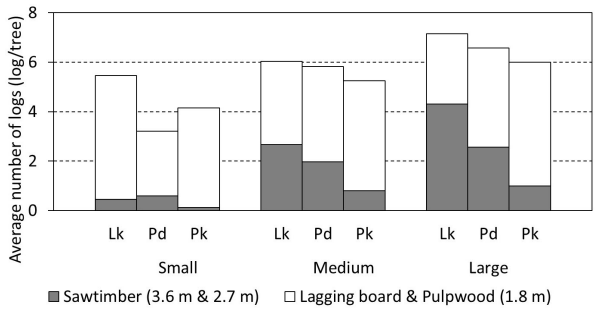

Fig. 2. Average number of logs per tree by DBH class.

anymore. It should be noted that the diameter of small end of 2.7 m and 3.6 m logs must be larger than 12 cm for *P. densiflora* and *P. koraiensis* and 9 cm for *L. kaempferi* for producing sawtimber (Korea Forest Research Institute 2013).

The short length logs of 1.8 m were produced from the residue after the production of 3.6 m and 2.7 m logs. Diameters of the lower and upper end of log were measured and the length of each logs was collected. The total height was computed by adding up the log lengths and the terminal length of the tree top. Therefore, DBH, total height, the number of logs by length, and diameters of the lower and upper end of logs were collected as the tree information in the field.

From the collected data, the number of logs by length and volume were calculated by species. The volume was computed by adding up the log volumes using Smalian's formula in every log. The number of logs by species was analyzed by DBH and height class. DBH class was classified with Small (DBH < 18 cm), Medium (18 cm ≤ DBH < 30 cm), and Large (DBH ≥ 30 cm) (Korea Forest Service 2017). Height class was classified with two groups higher or smaller than 15 m because this criterion is often used for sawtimber production in the field.

In addition, the upper diameter and upper height were compared in terms of logs for sawtimber production by species. In this study, it was considered that 2.7 m and 3.6 m logs were used for sawtimber and 1.8 m logs for lagging board and pulpwood. The residual part of tree, except for sawtimber, lagging board, and pulpwood, was defined as others (National Forestry Cooperative Federation 2017).

Results and Discussion

Log numbers by DBH and height class

The amount of log production for three species was analyzed by DBH and height class (Fig. 2). In small DBH class of all species, A few logs were produced for sawtimber. The logs for sawtimber started to be apparent from medium DBH class: 2.7 logs for *L. kaempferi*, 2.0 logs for *P. densiflora*, and 0.8 logs for *P. koraiensis* on average. In large DBH class the number of logs for sawtimber were noticeably different among species: 4.3 logs for *L. kaempferi*, 2.6 logs for *P. densiflora*, and 1.0 logs for *P. koraiensis* on average. The number of logs for lagging board and pulpwood were more than the logs for sawtimber in all species. As DBH class was increased, the amount of logs for lagging board and pulpwood are generally increased, but de-

creased in *L. kaempferi* because it was mostly used as the logs for sawtimber.

This tendency about the number of logs for sawtimber appeared similarly when height class was considered additionally (Fig. 3). In height ≥15 m with medium DBH class, the number of logs for sawtimber were 2.7 logs for *L. kaempferi*, 2.5 logs for *P. densiflora*, and 0.9 logs for *P. koraiensis* on average. The number of the logs were highly distinguishable by species in height ≥15 m with large DBH class: 4.3 logs for *L. kaempferi*, 2.7 logs for *P. densiflora*, and 1.0 logs for *P. koraiensis* on average. It was judged that the small number of samples for *P. koraiensis* influenced on the number of average logs in large DBH class as shown in the average DBH, 17.3 cm (Table 1). In general, *L. kaempferi* was produced the most number of logs for sawtimber among three species.

Merchantable volume ratio for sawtimber

Merchantable volume ratio by use was compared by categorizing sawtimber, lagging board and pulpwood, and others (Fig. 4). In small DBH class the merchantable volume ratio for sawtimber was low of 4% to 26% by species.

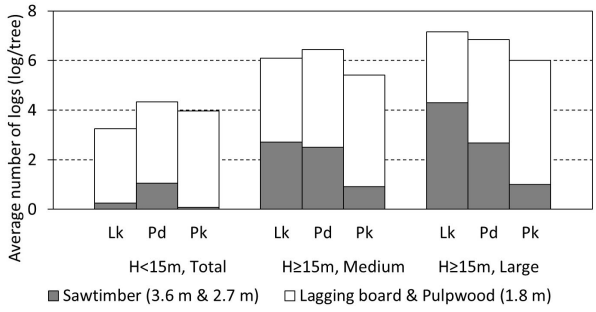

Fig. 3. Average number of logs per tree by DBH and Height class.

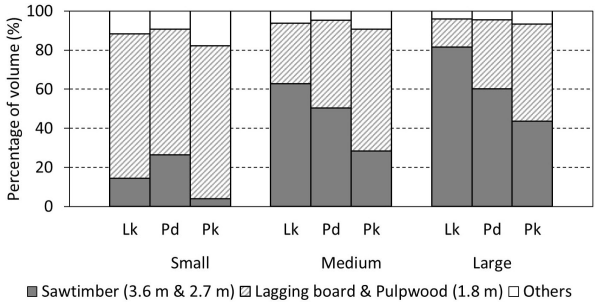

Fig. 4. Volume ratio by use according to DBH class.

The merchantable volume ratio was remarkably increased from the medium DBH class and it was 63% for *L. kaempferi*, 50% for *P. densiflora*, 28% for *P. koraiensis* on average. The merchantable volume ratio for sawtimber was more noticeably distinguishable in large DBH class. *L. kaempferi* produced 80% of volume ratio for sawtimber, followed by 60% for *P. densiflora* and 44% for *P. koraiensis*.

When height was also considered, this merchantable volume ratio for sawtimber was a little higher in height ≥15 m with medium DBH class: 63% for *L. kaempferi*, 57% for *P. densiflora*, and 33% *P. koraiensis*, respectively (Fig. 5). The merchantable volume ratio in height ≥15 m with large DBH class was 82%, 58%, and 44%, respectively, in the same order and similar to the merchantable volume ratio just in large DBH class. Most of merchantable volume in small DBH class was used for lagging board and pulpwood and the merchantable volume ratio decreased as DBH and height class increased.

With regard to the merchantable volume ratio for sawtimber, this order by species was identical with the order in the number of logs for sawtimber. Overall, the merchantable volume ratio was shown for sawtimber from the medium DBH class and was the highest in *L. kaempferi*. This result is analogous with the previous research, which reported *L. kaempferi* were used as sawtimber much more than *P. densiflora* and *P. koraiensis* (Kim 2017).

The ratio for sawtimber was higher in the amount of merchantable volume than in the number of logs. This was attributed to the procedure and priority of log production; logs for sawtimber were produced at first from the stem base with large volume and the residues were used to produce the logs for lagging board and pulpwood. The volume ratio for others decreased as DBH class increased, and

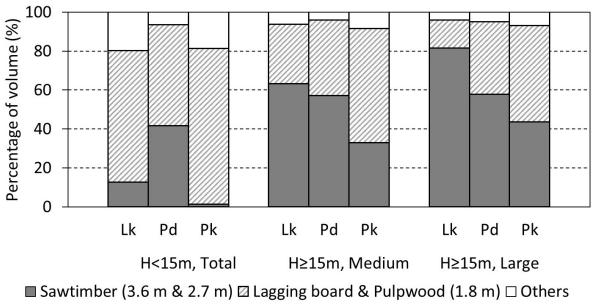

Fig. 5. Volume ratio by use according to DBH class and height class.

thus, large DBH class was considered more commercial.

Upper diameter and upper height limit for sawtimber

The upper diameter and upper height of last log for sawtimber were compared to find out the limit (Fig. 6). The limit of the upper diameter for sawtimber was 14.1 cm for *L. kaempferi*, 15.7 cm for *P. densiflora*, and 16.9 cm for *P. koraiensis* on average. The upper height was reversely shown: 12.2 m for *L. kaempferi*, 11.2 m for *P. densiflora*, and 6.0 m for *P. koraiensis* on average.

In consideration of this result, the limit of last log for sawtimber of *L. kaempferi* was less restricted because the last log can be produced in the limit at which upper diameter was smaller and upper height was taller.

It was considered straightness of *L. kaempferi* positively affected the limit of log production for sawtimber (Korea Forest Research Institute 2012c). Because the stem quality such as straightness, forked, sweep, crook, and broken top directly affects the log length for sawtimber production, tree investigation about stem quality is needed for the further study (Deadman and Goulding 1979; Choi et al. 2008).

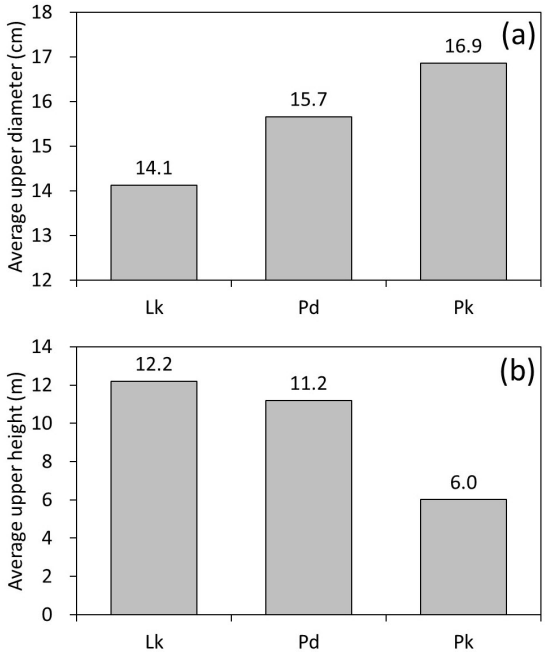

Fig. 6. Average upper diameter and upper height for sawtimber production.

Conclusion

This study was carried out to find out the number of logs and the merchantable volume ratio of *P. densiflora*, *P. koraiensis*, and *L. kaempferi* for sawtimber production. The number of logs for sawtimber basically increased in all species as DBH class increased and similar pattern was shown when height class was also considered. The number of logs for sawtimber were noticeably shown from medium DBH class and it was the largest in large DBH class: 4.3 for *L. kaempferi*, 2.6 for *P. densiflora*, and 1.0 for *P. koraiensis*.

The merchantable volume ratio for sawtimber increased with DBH and height class. Most of volume ratio was used for lagging board and pulpwood in small DBH class. The merchantable volume ratio for sawtimber evidently appeared from medium DBH class: 63% for *L. kaempferi*, 50% for *P. densiflora*, and 28% for *P. koraiensis*. In large DBH class the merchantable volume ratio for sawtimber was highest with 82% for *L. kaempferi*, followed by 60% for *P. densiflora* and 44% for *P. koraiensis*.

Finally, the limit of upper diameter and upper height was figured out for sawtimber production. The last log for sawtimber produced in *L. kaempferi* was the smallest in upper diameter and the tallest in upper height among three species. In conclusion *L. kaempferi* produced the most number of logs for sawtimber and was used as sawtimber for the most volume ratio than the other two species. The limit of upper diameter and upper height for sawtimber production was the least among three species, and so most of volume can be used as the logs for sawtimber. Overall, *L. kaempferi* was considered to be the most economical and productive species for sawtimber.

Acknowledgements

This study was carried out with the support of 'full-time faculty research project' funded by Kangwon National University in 2016 (Project No. 520160244) and the support of 'Science and Engineering Individual Basic Research Project (Project No. NRF-2016R1D1A1B02011648)' funded by National Research Foundation of Korea in 2017.

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