Analysis of the production potential of raw wood in the forests of Slovakia

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ABSTRACT: Production of raw wood material and its regulation has a great ecological and economic importance in every country. The aim of the paper is to analyze the prospective production of raw wood with respect to the expected basic tree species composition and assortment structure on an example of long-term development of selected indicators of forest condition in Slovakia. For this analysis we used data on the area, growing stock and planned decennial timber felling in the forests of Slovakia in 1980, 1996 and 2003. The production potential of forests was evaluated on the basis of the annual perspective allowable cut by 2020, from which the prospective production of assortments was derived using the models of assortment yield tables of tree species. The results show that in the forests of Slovakia there is an about half proportion of coniferous and half proportion of broadleaved tree species, very good structure of growing stock as well as its trend in the last years. Production of raw wood assortments for industrial processing for the years 2010–2020 is limited by the volume 6.3–6.4 mil. m³. About one half of this volume comes from coniferous and the other half from broadleaved tree species. For coniferous tree species the proportion of spruce and fir is 87% and for broadleaved tree species the proportion of beech and oak is 80%. For coniferous tree species sawmill assortments have a decisive, almost 70% proportion. Regarding broadleaved tree species, pulpwood assortments with 47% proportion prevail, although with 11% the highest quality assortments for the production of veneer from beech and oak are also significant.

Keywords: production of raw wood; allowable cut; production of raw wood assortments

Wood is a natural product of photochemical assimilation of carbon dioxide, water and solar energy; its further technological processing into final products and goods of final utility value is relatively simple and ecological. Therefore the production of raw wood material considering its regulation has a great ecological and economic importance in every country.

In the Slovakia considerable attention has been paid to the issues of wood production and regulation of its felling. Permanent forest monitoring, mainly of the growing stock in forest stands during continual renewal of forest management plans is a proof of that. This is also connected with the calculation of felling possibilities, i.e. of it allowable cut according to counties and for the whole country (Kanka 1985; Greguš 1989; Petráš, Mecko 1999). In addition to these final products of forest management, development of some methods and materials that were used for their processing needs to be mentioned. This covers a spectrum of the methods for monitoring growing stocks in forest stands as presented by Šmelko (2000) including a broad use of domestic yield tables (Halaj et al. 1987; Halaj, Petráš 1998), ages of rotation maturity and decennial thinning percents (Halaj et al. 1986, 1990) as well as empirical cutting percentages for regeneration timber felling (Greguš 1969). Methodical solutions of this field are relevant as cited by Herich and Hladík (1993), Herich (1994) and Marušák (1998, 1999) as well.

In Germany Polley et al. (1996) dealt with these issues in more detail. They derived allowable cuts by 2020 for the whole country as well as for the respective federal states. In former federal states their prognostic model was derived from the database on large-scale forest inventory carried out in 1986 to 1990, while for new federal countries the database of state, military and church forests of former democratic Germany updated in 1989–1993 was used. The obtained results are very valuable especially from the aspect of methodology since in one country two database sources with different contents and data structure were used for one purpose. Other authors, like Schwarzbauer (1994), Hinssen (1994), Siitonen (1995), Kupka (1995), Hradetzky (1995) and Nabuurs and Päivinen (1996), also dealt with the expected model of raw wood production.

The aim of this paper is to present how to derive the prospective production of raw timber, expected basic composition of tree species and structure of assortments on an example of forest condition in Slovakia.

MATERIALS AND METHODS

The material used in this study comprises data on forest area, growing stock and planned decennial timber felling in the forest stands of Slovakia in 1980, 1996 and 2003. The data are arranged into the sets according to age classes, groups of tree species (coniferous, broadleaved) and forest categories (commercial forests, special-purpose forests and protective forests). The material was provided by Lesoprojekt (1980, 1997, 2004) from its own central data bank on the forests of Slovakia, which is updated regularly every year using the data on the forest stand status obtained from the renewal of forest management plans. Data on the area of about $^1/_{10}$ of Slovak forests are updated every year in this way.

For the purpose of the production potential analysis, average decennial cutting percentages DC of tending and regeneration felling were calculated as regards the years 1980, 1996 and 2003 pursuant to the formula:

$$DC\% = \frac{DC}{V} \times 100 \tag{1}$$

where:
DF – planned decennial cutting according to forest management plan (m³),
V – growing stock (m³).

The utilization of forest production potential was evaluated from the annual prospective allow-able cut AC that was calculated by the year 2020 as follows:

$$AC = \frac{DC\%}{1,000} \times V \tag{2}$$

where:
$DC\%$ – decennial cutting percentage according to formula (1),
V – growing stock (m³).

Cutting percentages from formula (1) were calculated for all sets of stands arranged to age classes, groups of tree species and forest categories. In addition, one-year allowable cuts in the interval of the calendar years 2003–2020 were calculated for these sets**.** Petráš and Mecko (1999) presented the detailed calculation procedure.

The prospective production of assortments was derived from prospective allowable cuts by 2020 and from the models of assortment yield tables of tree species (Petráš et al. 1996) that give the proportion of quality and diameter classes of logs in stands with regard to their age and site index. According to the external and internal quality of timber assortment tables distinguish 6 quality classes of logs with prevailing industrial processing for:

I – sliced decorative veneers for the production of furniture, special sport and technical needs,
II – peeled veneers, matches, wooden barrels,
III – poles, building timber and saw logs that are divided into higher IIIA and lower IIIB quality class,
V – production of pulp, cellulose and agglomerated boards,
VI – fuel.

To assort calamity wood (snags and windthrows) of coniferous tree species we used the arrangement of the assortment structure by Halaj et al. (1990) and Petráš et al. (1995). For coniferous tree species the proportion of salvage felling for the years 1986–2002 was about 50–80%, out of which about one half comes from windthrows and the other half from snags. In the case of broadleaved tree species salvage felling was only 14–34%. From these values we estimated the future trend of salvage felling by 2020, namely for conifers its proportion was estimated at about 60%, and of this one half for windthrows and one half for felling of snags. For broadleaved tree species we estimated the proportion of salvage felling to be approximately 25%, but since no objective data were available, their assorting has not been carried out.

RESULTS AND DISCUSSION

For the illustration and examination of long-term development of forests basic data were processed.

Table 1. Stand area and growing stock in the forests of Slovakia in 1980, 1996 and 2003

Year	Tree species	Stand area		Growing stock of large wood under-bark		
		(ths ha)	(%)	(ths m^3)	(%)	(m^3/ha)
1980	coniferous	801	43	168.595	53	210
	broadleaved	1,061	57	150.075	47	141
	total	1,862	100	318.670	100	171
1996	coniferous	802	42	187.781	50	234
	broadleaved	1,122	58	189.732	50	169
	total	1,924	100	377.513	100	196
2003	coniferous	785	41	202.638	47	258
	broadleaved	1,144	59	225.643	53	197
	total	1,929	100	428.281	100	222
Change 1980–2003	coniferous	−16	−2.0	+34.043	+20.2	+48
	broadleaved	+83	+7.8	+75.568	+50.4	−
	total	+67	+3.6	+109.611	+34.4	+51

Table 1 presents the development of two basic production indicators, namely the area of forest stands and growing stock in 1980–2003. It is obvious that while the area of forest stands increased only by 3.6% for the mentioned period, growing stock increased by 34.4%. An extremely high increase of growing
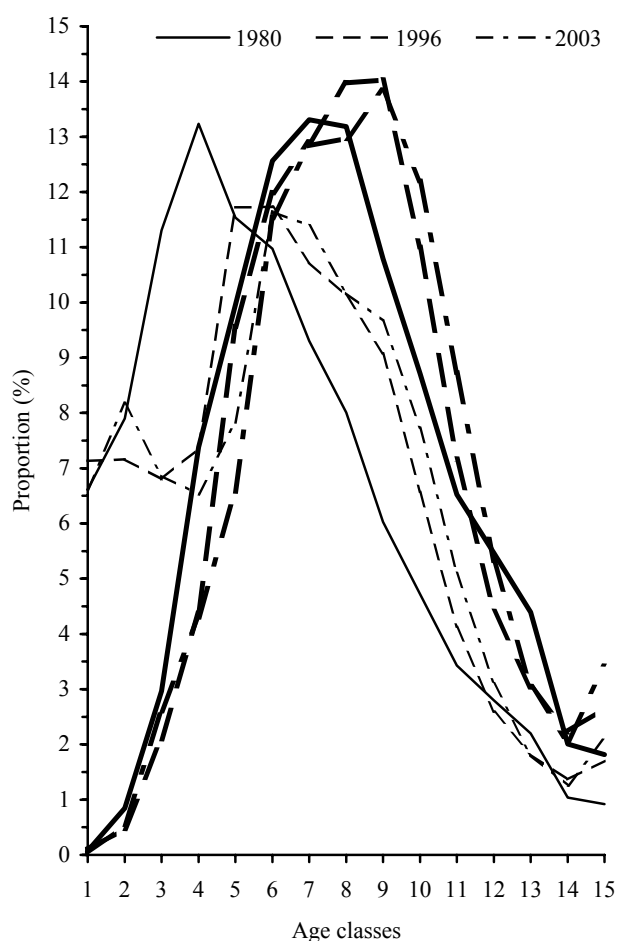

Fig. 1. Proportion of stand area (thin line) and growing stock (thick line) of broadleaved tree species in age classes in 1980, 1996 and 2003
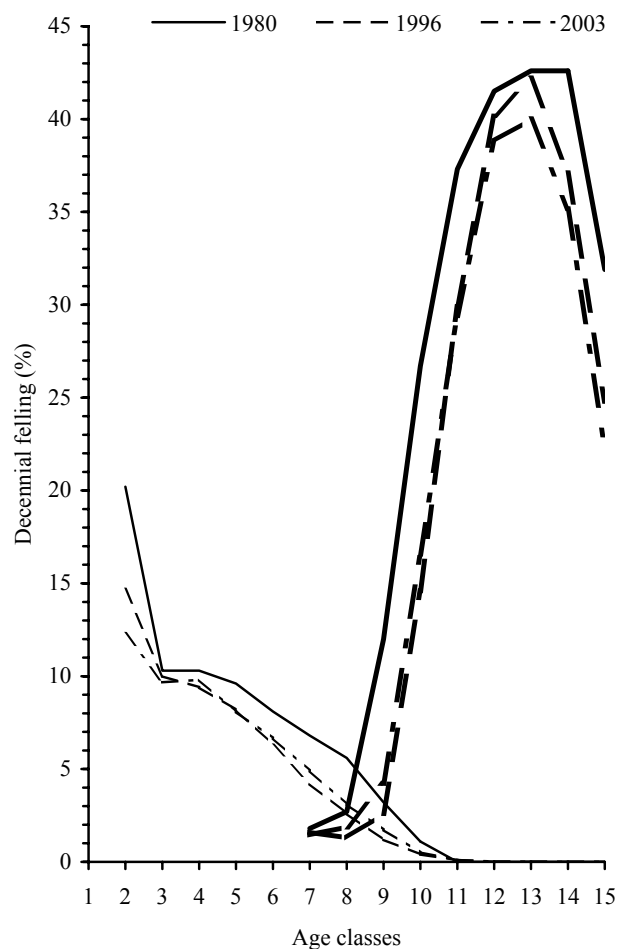
Fig. 2. Planned decennial percents of tending (thin line) and regeneration timber felling (thick line) of broadleaved tree species in age classes in 1980, 1996 and 2003
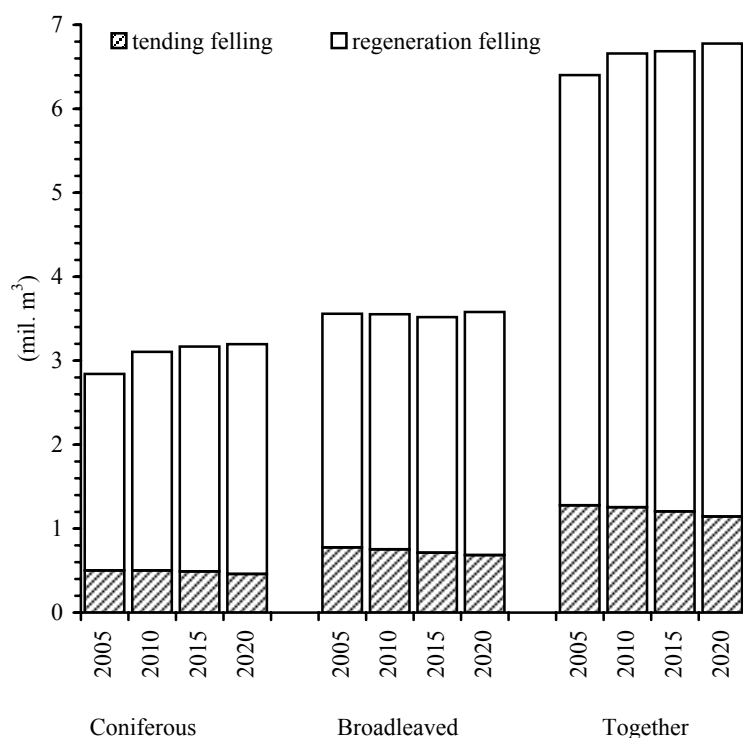
stock, by 50.4%, was recorded for broadleaved tree species when compared with the year 1980. In comparison with the development of growing stocks in other countries (SPIECKER et al. 1996) this is not a surprising fact. In Slovakia this increase can mainly be caused by introducing domestic yield tables (HALAJ et al. 1987; HALAJ, PETRÁŠ 1998) into the practice of forest management in 1990 in the whole territory of Slovakia. Since 1990 the growing stock in most stands has been determined using these yield tables. For the observation period, the proportion of broadleaved tree species increased at the expense of conifers from 57% to 59% and from 47% to 53% when we derived it from stand area and growing stock, respectively.

To evaluate prospective allowable cuts of timber felling, the time continuity of long-term development of stand area, growing stock and intensity of timber felling is very important. As an example Fig. 1 represents the development of the proportion of stand area and growing stock of broadleaved tree species in age classes for the years 1980–2003. We can see that the shift of all curves by 1–2 degrees higher is not mechanical. Changes in the area distribution of age classes occurred mainly due to the realization of regeneration felling, including salvage felling in the stands of lower age classes. Dynamic changes in the distribution of the growing stock to individual age classes are obvious, since their culmination shifted from 7th to 9th age class. In addition, in age classes 2–8 the proportions of growing stock

decreased by about 6%, while in age classes 10–12 its increase can be seen.

The intensity of timber felling was evaluated according to decennial cutting percentages calculated from formula (1). Their values for the category of broadleaved commercial forests are illustrated in Fig. 2. It is obvious from the data that the highest cutting percentages for tending as well as regeneration felling were recorded in 1980. In 1996 the cutting percentages of tending felling were lower by 1–3% when compared with 1980, and for regeneration felling almost by 12% in some age classes. The differences between the years 1996 and 2003 are smaller.

Fig. 3 represents the development of perspective allowable cuts calculated according to formula (2). The volume of tending felling for the years 2005 to 2020 slightly decreased, in coniferous tree species by about 0.5–0.4 mil. m^3 and in broadleaves by 0.8 to 0.7 mil. m^3. Allowable cut of regeneration felling slightly increased, namely in coniferous tree species by 2.3–2.7 mil. m^3 and in broadleaves by 2.8 to 2.9 mil. m^3. The volume of tending felling for coniferous and broadleaved tree species together was 1.3 to 1.1 mil. m^3 and of regeneration felling 5.1 to 5.6 mil. m^3. From the total timber felling of 6.4 to 6.8 mil. m^3 the proportion of tending felling slightly decreased by 20–17% and the proportion of regeneration felling slightly increased by 80–83%. This relatively low proportion of tending felling and high
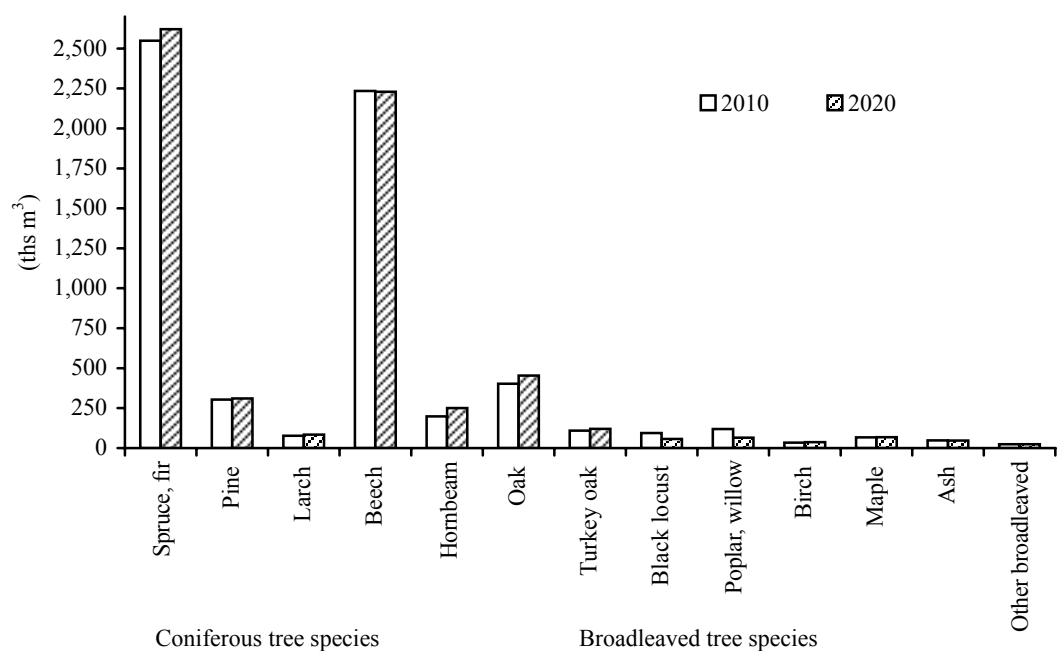
Fig. 4. Prospective prognosis of the production of quality classes of logs *I–V* for the years 2010–2020 according to tree species

proportion of regeneration felling as well as almost the same composition of coniferous and broadleaved tree species show a very high production potential of the forests in Slovakia for the following 15 years.

From total allowable cuts in 2010–2020 with the volume 6.6–6.8 mil. m³ the volume of assortments suitable for industrial processing was derived using the assortment models, namely quality classes of logs *I–V* in the volume of 6.3–6.4 mil. m³, which makes about 94% of the total allowable cut. From

the remaining volume, approximately 4% represent quality class *VI*, i.e. fuel wood, and 2% is wood not suitable even as fuel, i.e. waste wood.

Fig. 4 illustrates volumes of quality classes of logs *I–V* together for individual tree species for the whole Slovakia. The highest volume in 2010, about 2,500 ths m³, is expected for spruce with fir, followed by beech with 2,200 ths m³. The following tree species are oak with about 400 ths m³, pine with 300 ths m³ and hornbeam with 200 ths m³. Other
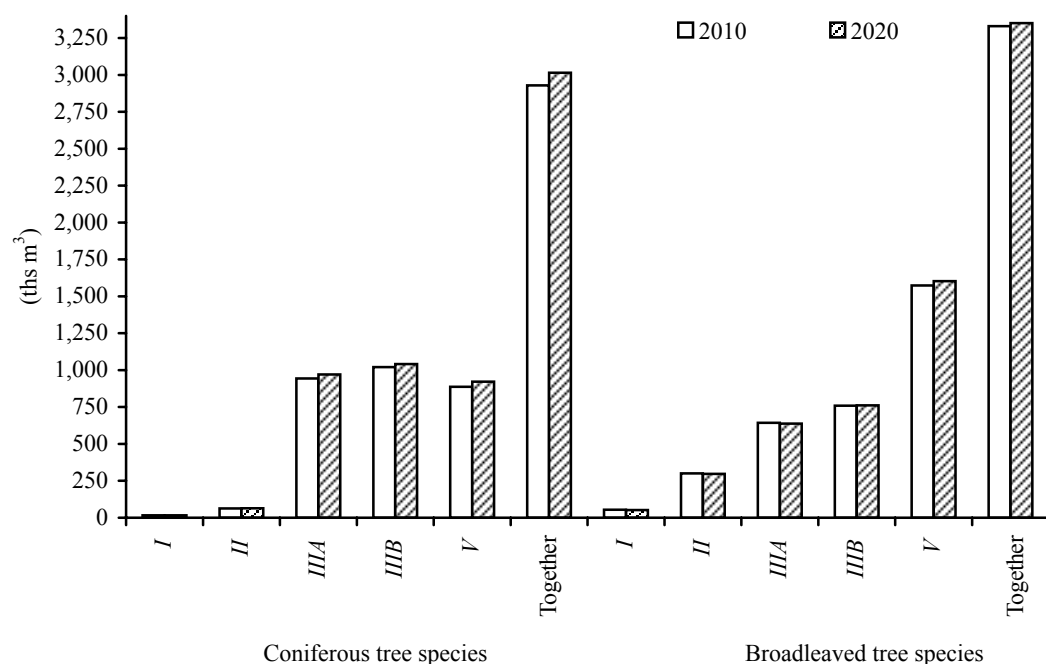

Fig. 5. Prospective prognosis of the production of quality classes of logs for the years 2010–2020

tree species reach substantially lower volumes in the range of 20 to 100 ths m³. By 2020 a slight increase in the volumes by 50–70 ths m³ for oak, hornbeam and spruce with fir is expected, while the volumes of black locust and poplar decrease by 40–50 ths m³. Other tree species will reach approximately the same volume.

As Fig. 5 documents, in the interval of the years 2010–2020 and in the category of coniferous tree species we expect the volume of about 2,900 to 3,000 ths m³ to be of quality classes I–V. Out of this volume about 890–920 ths m³ is in quality class V, 940 to 970 ths m³ in quality class IIIA and 1,020 to 1,040 ths m³ in quality class IIIB. Regarding saw timber classes IIIA, IIIB about 8–15% is in the 1st diameter class. The volume of quality classes of logs I and II is only 16 and 64 ths m³, respectively. The same figure illustrates the volumes of quality classes of logs for broadleaved tree species as well. Their total expected volume makes approximately 3,300 ths m³, out of which 1,600 ths m³ belong to quality class V. In quality class IIIA and IIIB there is about 650 to 750 ths m³, while 8–11% are of the 1st diameter class. About 300 ths m³ is in quality class II and 50 ths m³ in quality class I. While for coniferous tree species the total volume of quality classes I–V increases by about 100 ths m³ for the years 2010–2020, for broadleaved tree species this change will be relatively small.

CONCLUSIONS

To derive the allowable cuts distribution of growing stock by age classes and intensity of timber felling is the most important. Based on the presented analysis we can state that the forests of Slovakia have very suitable tree species composition, structure of growing stock by age classes as well as the dynamics of their development in the last years.

Production of raw timber assortments for industrial processing is limited by total timber felling. For the years 2010–2020 we expect the felling volume 6.3–6.4 mil. m³ together for all quality classes I–V. Approximately one half of this volume is for coniferous tree species and the other half for broadleaved tree species. For coniferous tree species quality classes I–II account for about 3%, quality class III for 67% and class V for 30%. For broadleaved tree species quality classes I–II account for about 11%, quality class III for 42% and class V for 47%. Regarding coniferous tree species, spruce with fir account for the decisive proportion of 87%, while in the group of broadleaves beech with oak account for 80%. It means that saw timber assortments of quality classes IIIA and IIIB make the decisive, almost 70% proportion of the volume of coniferous tree species. Although in the case of broadleaved tree species pulp assortments of quality class V prevail, an 11% proportion of quality classes I–II, i.e. of the highest quality assortments of beech and oak, is worth mentioning. Though during the derivation of allowable cuts and potential production of the assortments of raw timber several factors were considered, including the relatively high proportion of salvage felling of coniferous tree species, it is difficult to forecast their development more accurately. Specific conditions in the management of forests will be decisive. These can be considerably influenced by high salvage felling as well as by the conditions for the realization of mainly tending timber felling. Market conditions will be important as well, as they can significantly affect not only the total volume of raw timber but also the structure of assortments.

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Analýza produkčného potenciálu surového dreva v lesoch Slovenska

ABSTRAKT: Produkcia drevnej suroviny vrátane jej regulácie má v každej krajine veľký ekologický a hospodársky význam. Cieľom práce je na príklade dlhodobého vývoja vybraných ukazovateľov stavu lesov Slovenska analyzovať výhľadovú produkciu surového dreva vrátane očakávanej základnej skladby drevín a štruktúry sortimentov. Materiál tvoria údaje o výmere, zásobe a plánovanej decenálnej ťažbe dreva v lesoch Slovenska v rokoch 1980, 1996 a 2003. Produkčný potenciál lesov sa posudzoval podľa ročného výhľadového etátu ťažby dreva do roku 2020. Z neho sa podľa modelov sortimentačných rastových tabuliek drevín odvodila výhľadová produkcia sortimentov. Výsledky dokazujú, že v lesoch Slovenska je približne polovičné zastúpenie ihličnatých a listnatých drevín, veľmi dobrá štruktúra zásob dreva, ale aj jej vývoj v posledných rokoch. Produkcia sortimentov surového dreva na priemyselné spracovanie pre roky 2010–2020 je limitovaná objemom 6,3–6,4 mil. m³. Približne polovica z tohto objemu je pre ihličnaté a polovica pre listnaté dreviny. V ihličnatých drevinách má rozhodujúce 87% zastúpenie smrek s jedľou a v listnatých 80% buk s dubom. Pri ihličnatých drevinách majú rozhodujúci, takmer 70% podiel piliarske sortimenty. Pri listnatých drevinách prevažujú s 47 % vlákninové sortimenty, ale významný je aj 11% podiel najkvalitnejších sortimentov na výrobu dyhy z buka a duba.

Kľúčové slová: produkcia surového dreva; etát ťažby dreva; produkcia sortimentov surového dreva

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