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Impact of Sustainable Management of Natural Even-Aged Beech Stands on Assortment Structure of Beech in Croatia

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1. Introduction

When considering assortment structure of the main forest products and the compilation of assortment tables, continuous patterns of biological growth and development of stands (trees) come into conflict with the provisions of the standards for the classification of forest wood products and common practices in wood trade, prescribed by man and changeable with time. Actually the Croatian forestry faces additional uncertainties brought by the application of new standards on our beech stands.

The quantity and quality of broadleaved wood assortments are highly affected by the diversity of habitus and occurrence of faults on and in the tree. Proper development of individual trees and stands is provided by harmonized effects of biotic and abiotic factors. Disturbance of this harmony as a rule causes the occurrence of faults that highly affect the quantity and quality of wood assortments. The occurrence of faults, their size and number, is of random character and it cannot be correlated with measurable tree parameters. Excluding heritage properties, habitus and faults are the result of conditions in which the tree grew until the time of felling. In an organized forestry, the time of felling is different for individual trees. From the standpoint of forest silviculture and harvesting, the determination of the felling time for individual trees (selection, marking by which a specific type of cut is performed) represents the most significant influence of man on stand relationships, and also on the structure of wood assortments.

The tables showing the share of forest wood assortments (assortment tables) are a significant tool necessary for the forestry staff, and common beech is the most represented species in the Croatian forests. When planning fellings and annual allowable cuts, it is necessary to know the quantity and quality of wood assortments, determined in accordance with the applicable standards for the products of forest harvesting. Reliable and usable tables of wood assortments are necessary for the assessment of efficiency of the process of forest harvesting of a certain area, and also for the comparison of work activities performed by specific parts of enterprise. Due to the diversity of their phenotype, broadleaved species are more demanding than conifers with respect to the investigation of assortment structure, i.e. the possibility of achieving the quality of forest wood assortments.

According to Benić (1987) forest assortments are standardized products determined by standards, common practices and trading habits, and they can also be determined by agreement between the producer and purchaser. The products of wood processing are determined by wood species, form of cross-cut, dimensions, method of processing, quality and possible quality deviations. Assortment structure of the stand is determined by assortment shares of individual trees. The selection of trees for felling during rotation is not the result of random decisions, but rather a procedure based on rules and principles arising out of forest management. These rules and principles are the result of a comprehensive scientific development of forestry profession. If the operations of forest workers are based on science, clear (measurable) results of such operating procedure must be obtained. In science, it is considered that the most objective research is the one whose results may be expressed numerically (Kelvin, 1953). For these reasons, with even-aged beech stands, it is more convenient to investigate the assortment structure of individual types of cut (cutting sites) than the assortment structure of the stand. Only with clean cuts and in stands before the final felling, these two expressions have the same meaning.

In forest management, the forestry profession applies the principle of sustainability or the principle of sustainable development. In this way, by operations of forest tending, the existing forests are developed, and by operations of regeneration and reforestation new generations of forests are grown. Natural management is based on operations of forest tending and regeneration whose basic principles can be found in virgin forest. Forests managed in this way represent a strong ecological and economic foothold in all, even unfavorable, life conditions. If from its origin, the forest has been developed under the influence of man who carries out the operations of tending and regeneration based on natural principles, then we talk about natural forest management. (Matić, 2009).

By forest management, man affects directly the assortment structure of stands. According to Matić & Skenderović (1992) in carrying out silvicultural operations of forest tending, difference should be made between positive and negative selection. Tending of stands and trees is based on the fact that the tree phenotype is the result of genotype and impact of the environment or stand conditions. By tending, the spontaneous selection of trees in a stand is replaced by selection based on silvicultural principles. Negative selection is aimed at observing and removing from the stand all unwanted plants until the age when the trees of future can be identified (stand carriers), and after that positive selection is applied by which everything that prevents the development of the identified trees of future is eliminated from the stand. Negative selection involves providing more light to seedlings and cleaning of saplings and young growth. Positive selection involves thinning in mature young-growth, young, medium-aged, older and old stands, and then follow the procedures of natural regeneration (reforestation) of stands by preparatory, seeding and finishing felling. The selection criteria of marking trees for felling is also applied in preparatory felling where trees that decrease or prevent ripening of the best trees and trees whose self seeding is not wanted (less wanted species and similar) are removed. After that, in seeding, shelterwood and final fellings, the decisive role in making decision on marking trees for felling is given to seeding of reforestation area and gradual providing of light to seedlings and saplings, which is regulated by space distribution of the remaining trees in the regeneration area.

The impact of management on the structure of beech stands and production of wood can be clearly seen through almost two centuries of organized forestry in the research area, i.e. the fact that we no longer manage virgin forest stands that developed with minimum or no human assistance. On the other hand, it is a fact that forestry has always known how to implement natural management in Croatian forests. This is best proved by the preservation of their natural structure and diversity that are especially conspicuous in forests where forest management has been applied continuously for almost two centuries and a half. Natural approach to forest management in Croatia can be can be seen in the Zagreb School of Forest Silviculture applied and developed by the Faculty of Forestry of the University of Zagreb (Matić & Anić, 2009).

Fig. 1. Young (5 years) and old (100 years) natural beech stands

Common beech is a broadleaved species and with aging it almost always develops false heartwood, which complicates additionally the investigation of its assortment structure. Roundwood faults are related to irregularities in structure, texture, color and consistency. They reduce technical properties, make processing difficult and decrease the degree of wood utilization. Some wood faults are created as the effect of the phenomenon of growth and development of the tree so that the term "wood fault" is relative. European beech is the tree species of one color, whose aging generates optionally or always colored heartwood of irregular shape. Such colored beech heartwood is called false heartwood, red heartwood, brown heartwood or corewood (*Figure 2*). In Croatia, local population also use the term „kern" (from the German noun der Falschkern – false heartcore).

Fig. 2. Different shape of beech false heartwood

Beech false heartwood, as the phenomenon that affects considerably the quality of industrial wood, has been the object of professional and scientific interest for more than 100 years (Krpan et al., 2006). Numerous theories and interpretations of the formation of false heartwood are hypothetical even today. As stated by Glavaš, Tusson (1905) supposes that false heartwood of beech is formed as the reaction of wood cells to the attack of fungi. It was established later that the primary cause of formation of false heartwood in beech trees is not a biotic but rather an abiotic factor. The formation of false heartwood of beech is the effect of reaction of living wood cells to the penetration of air or oxygen into the tree trunk. Oxygen acts as poison on living cells, and they defend themselves by anatomical and chemical changes (tyloses, oxidation, formation of colored substances) trying to prevent further penetration of air. Substances formed as the result of such cell reactions are not introduced into cell walls, but deposited on them, and this is the basic difference between true and false heartwood (Glavaš, 1999).

The factors of formation of all types of heartwood are divided into obligatory and optional. For the formation of false heartwood, a certain quantity of air must penetrate into the inside of the tree. Optional factors are as follows: natural aging of parenchyma cells, excessive penetration of air into the tree, low temperatures (along with a serious draught in the previous summer), presence of fungi that destroy wood and fungi that change wood color, genetic predispositions and forest silvicultural measures and other human impact. The occurrence and development of individual types of false heartwood is not always caused by influence of one factor only, but rather by a combination of several factors. It has been confirmed that there is a correlation between the formation and degree of development of false heartwood and tree physiology. In the last twenty years, the then knowledge has been considerably updated by Torelli's researches (1984, 1994). According to this author, false heartwood of beech is caused by environmental impact, and all factors that cause the reduction of water content in the inside of the tree trunk are responsible for its formation. At the age between 80 and 90 of beech trees (depending on growth conditions), a certain disruption of physiology balance occurs. At that age, the leaf area and root system of beech trees are not enlarged anymore, despite the diameter increment. This leads to the disruption of balance of the water regime inside the tree and the central part of the tree trunk dehydrates. The process of dehydration of the central part of the tree trunk is, from the physiological aspect, similar to the genetically conditioned formation of false heartwood. The following factors are crucial for the development of false heartwood of beech: the size of tree top and tree diameter, i.e. quick growth of the tree and intensity of tree top reduction. The development of false heartwood is also affected by the soil condition, position, social status of the tree and tree top height. The process of false heartwood formation starts much later on soils of poor quality. Any mechanical damages of trees with dehydrated central part result in the penetration of oxygen into the tree by which the enzymatic process of tyloses formation is initiated.

The share of false heartwood in beech industrial roundwood has a considerable impact on the quality of beech logs. The differences in the quality of discoloured and optionally colored heartwood (false heartwood), under assumption that wood with optionally colored heartwood is sound, are almost the same as differences in characteristics of discoloured and obligatorily colored heartwood. The boundary line of false heartwood does not correspond to the boundary line of the growth ring. At the cross section the boundary line of false heartwood may be radial, star-like and completely irregular. False heartwood may be differently nuanced and it is not always symmetrical with respect to the longitudinal axis of the tree trunk, and drying causes considerable change of color. The largest diameter of false heartwood (red heart) appears between the 1st and 4th meter from the stump, and thereafter it decreases towards the stump and tree top. There is another increase of the diameter of read heart, although lower, between the 6th and 8th meter of tree trunk. In beech tree trunk false heartwood has the form of two cones connected by their bases, and however this shape is not necessarily regular (*Figure 3*). It achieves the greatest width at the point where the formation started (Tomaševski, 1958).

Fig. 3. Distribution of beech false heartwood in the trunk

Conductive elements in parts of wood attacked by false heartwood are blocked by tyloses, and consequently the impregnation can hardly penetrate into the wood (Govorčin et al., 2003). The impregnated beech wood with false heartwood is, therefore, highly susceptible to decay. Right due to susceptibility to decay of beech wood with false heartwood, this phenomenon is extremely important in practice and in wood trading (Glavaš, 1999, 2003). A specific kind of decay in beech trees with false heartwood is the phenomenon of specific white rot. It occurs when rot fungi penetrate into wood through wounds, broken branches, front end of logs, etc., and then develops inside the wood. White rot of beech trees is caused by different types of specific fungi, and most commonly they are as follows: *Schizophyllum commune* Fr., *Hypoxylon coccineum* (Pers.) Wind., *H. fragiforme* (Person ex Fries) Kicky, *Tremella faginea* Britz., *Stereum purpureum* Pers., *Biospora monilioides* Corda and others. White rot in wood with false heartwood is not spread evenly but rather in the form of a leaf, tongue or similar. The reason lies in the fact that different parts of beech wood are differently affected by false heartwood and tyloses and hence they offer different resistance to rot fungi. However, false heartwood cannot prevent the rotting process. It only makes the rotting process slower and more uneven. (Glavaš, 1999, 2003).

The share of false heartwood is prescribed for industrial roundwood by Croatian standards (for wood assortments and quality classes except those of the lowest value), and it is assessed or measured on the front end of industrial roundwood by measuring the diameter of the part where false heartwood is formed and by expressing it in centimeters or as the percentage of the diameter (area) at the place of measurement.

The presence and share of false heartwood in beech trees is unknown until the tree is felled and industrial roundwood processed. From the standpoint of forest harvesting and knowledge of quality or assortment structure of beech stands, the interest in the origin and development of false heartwood of beech trees is quite understandable. Although it has been known for some time that beech coming from Bilogora is highly appreciated in the market due to low presence of false heartwood. Right because it is unknown until felling and processing of trees, false heartwood represents an additional problem in planning revenues and in considering issues related to assortment structure of beech. For these reasons, it is necessary to expand the current knowledge with the information on frequency of occurrence of false heartwood and its impact on the quality of wood assortments by diameter classes based on the age of our even-aged stands and type of cut. It can be concluded that with this respect common beech is the most demanding autochthonous species in Croatia.

Compilation, precision and application in practice of tables showing shares of forest assortments in the annual allowable cut (assortment tables) are connected with serious and numerous difficulties caused by the influence of biotic and abiotic factors on stand development. Reliable and applicable assortment tables should take into account as many factors as possible. Among biotic factors, one of the most important is the impact of man through management, i.e. through implementation of criteria for marking trees by which a certain type of cut is performed. Consequently, it can be concluded that our primary interest, in terms of operating (production) activities, is the assortment structure, which can be achieved by implementing certain types of felling at a certain age of the stand, and not the assortment structure of all trees in the stand of a specific age. The efforts to achieve the best possible quality of all trees in the stand of a specific age are the basis of all management procedures of even-aged beech stands, carried out by work of many generations of forestry experts.

2. Research place and methods

2.1 Place of research

Regarding the ownership title, the economic forests in the Republic of Croatia can be generally divided into state-owned forests and privately owned forests. The aim of „Hrvatske šume" ltd and private owners is to manage forests by preserving and upgrading their biological and environmental diversity and to protect the forest ecosystem. In Croatia forests and forest land owned by the Republic of Croatia are managed by „Hrvatske šume" d.o.o., and for the purpose of performing a part of activities in public domain and improving forest management of forests and forest land of private forest owners a Forest Extension Service has been established.

In the widest sense, the state forests of Forest Administration Branch Office (FABO) Bjelovar involve the area of Northwest (Central) Croatia, they cover a total area of 131.820 hectares and they are located in seven counties: Bjelovar and Bilogora, Brod and Posavina, Koprivnica and Križevci, Požega and Slavonia, Sisak and Moslavina, Virovitica and Podravina and Zagreb county. These forests owned by the Republic of Croatia are managed by „Hrvatske šume" ltd Zagreb through Forest Administration Branch Office Bjelovar. The whole area is divided into 15 forest offices and 34 management units.

In the total growing stock of these forests of almost 33.000.000 m^3, common beech is the most represented species with the growing stock of almost 12.000.000 m^3 or 36 %. The total current annual increment is around 910.000 m^3 with the share of beech of approximately 328.000 m^3 or 37 %. Beech in forests of this area is vital and healthy. This is highly supported by the information on the average 3,3 % of occasional beech felling compared to the annual allowable cut of beech in the area of FABO Bjelovar in the period

2001 to 2009. Within a limited research area (Forest Office Bjelovar) for the same period the average annual share of accidental felling in the annual allowable cut of beech was only 2,3 %.

In the period between 2007 to 2010 forests owned by private forest owners in the Republic of Croatia was under the control of the Forest Extension Service. Since 2010. care for the forests owned by private forest owners in Croatia is returned to the State company „Hrvatske šume" and the Forest Extension Service has been called off. As well known, the Republic of Croatia has a relatively high percentage share of areas covered with forests and forest land (approximately 44 %) compared to the total land area. On the other hand, the share of private forests in the total forested areas of approximately 22 % is significant, and still not so high compared to some neighboring countries that have a considerably higher share of private forests (Slovenia 80 %, Hungary 40 %, etc.).

The surface area of private forests, or forests owned by forest owners in the area of Bjelovar and Bilogora County has not been precisely determined yet, and it is estimated to approximately 20.000 ha. Two developed management programs that are related to a restricted area of Bjelovar (for management units Bjelovarske šume and Trojstvo) cover the total surface area of private forests of approximately 3.000 hectares with the growing stock of almost 450.000 m^3 and 10-year allowable cut of approximately 100.000 m^3. The average growing stock in these two management units is 163 m^3/ha (for MU Bjelovarske šume) and 199 m^3/ha (for MU Trojstvo), respectively, which is more than the estimates used before the development of the management programs. The fact that private forests definitely need professional assistance is also supported by the mixture ratio of tree species where the most represented species are allochthonous locust with more than 30 %, hornbeam with approximately 20 % and soft broadleaved species (lime, alder, etc.) with approximately 15 to 20 % share in the total growing stock. The share of the most significant autochthonous species is small. The share of beech in the growing stock ranges between 6 % (MU Bjelovarske šume) and 10 % (MU Trojstvo). The share of pedunculate oak is up to 4 %, and sessile oak up to 7 %. The key problems of management in this area, too, are caused by fragmentation of forest holdings so that almost 12.000 owners have an average property of 0,23 hectares (MU Bjelovarske šume) to 0,28 hectares (MU Trojstvo). All this speaks of significant differences between private and state forests in this area, and also of considerable, but insufficiently utilized, resources of private forests.

The research was carried out in the management unit „Bjelovarska Bilogora" of Forest Office Bjelovar (FABO Bjelovar). All research compartments belong to the ecological-management type II-D-11 and management class BEECH with a 100-year rotation, whose share in the surface area of the management unit is 76,1 %, and in the growing stock 80,6 %. The management unit „Bjelovarska Bilogora" is located on Southwest and South slopes of Bilogora, at the altitude ranging between 115 m and 307 m above sea level. Its total surface area is 7.632,62 ha, of which 7.444,17 ha is stocked. The management unit is divided into 180 compartments and 533 sub-compartments. In 2003 the total growing stock was 2.317.147 m^3. In the growing stock, the beech as the most represented species accounts for 1.036.386 m^3 or 44,73 %. The total 10-year allowable cut for I/1 management semi-period is 586.231 m^3, of which 443.752 m^3 is main felling, and 142.479 m^3 is thinning. The share of beech in the 10-

year allowable cut is 297.753 m³ (67,2 %) in the main felling and 45.939 m³ (32,2%) in thinning, or a total of 343.692 m³ (58,6 %).

The total allowable cut of the main felling of the Forest Administration Branch Office Bjelovar is approximately 400.000 m³ with the share of beech considerably higher than 50 %. The total felling in the period 2001 to 2009 in the area of Forest Administration Branch Office Bjelovar can be seen in Table 1.

Year	Beech						Allowable cut				
	Main felling		Thinning		Total		Main felling		Thinning		Total
	m^3	%	m^3	%	m^3	%	m^3	%	m^3	%	m^3
2001.	122.384	60,4%	80.340	39,6%	202.724	***33,7%***	325.923	54,1%	276.139	45,9%	602.062
2002.	129.999	59,0%	90.525	41,0%	220.524	***35,7%***	289.554	46,9%	327.778	53,1%	617.332
2003.	171.831	69,6%	74.934	30,4%	246.765	***40,0%***	338.814	54,9%	278.530	45,1%	617.344
2004.	184.957	72,1%	71.729	27,9%	256.686	***39,6%***	366.680	56,5%	282.180	43,5%	648.860
2005.	192.115	70,6%	79.925	29,4%	272.040	***41,2%***	339.610	51,4%	320.912	48,6%	660.522
2006.	205.372	71,2%	82.895	28,8%	288.267	***43,6%***	383.765	58,0%	277.367	42,0%	661.132
2007.	199.731	70,9%	81.923	29,1%	281.654	***41,7%***	388.054	57,4%	288.013	42,6%	676.067
2008.	226.122	72,4%	86.313	27,6%	312.435	***45,8%***	375.802	55,1%	306.020	44,9%	681.822
2009.	227.579	74,6%	77.307	25,4%	304.886	***43,9%***	413.830	59,6%	280.435	40,4%	694.265
Total	1.660.090	69,6%	725.891	30,4%	2.385.981	***40,7%***	3.222.032	55,0%	2.637.374	45,0%	5.859.406

Table 1. Felling from 2001 to 2009 – Forest Administration Branch Office Bjelovar

Year	Beech						Allowable cut				
	Main felling		Thinning		Total		Main felling		Thinning		Total
	m^3	%	m^3	%	m^3	%	m^3	%	m^3	%	m^3
2001.	13.570	55,1%	11.048	44,9%	24.618	***39,7%***	30.991	50,0%	31.011	50,0%	62.002
2002.	6.447	61,8%	3.992	38,2%	10.439	***21,7%***	23.789	49,5%	24.243	50,5%	48.032
2003.	27.702	84,7%	5.018	15,3%	32.720	***47,9%***	43.746	64,0%	24.603	36,0%	68.349
2004.	30.567	87,7%	4.281	12,3%	34.848	***48,4%***	49.513	68,8%	22.426	31,2%	71.939
2005.	36.268	92,1%	3.110	7,9%	39.378	***51,3%***	49.766	64,8%	27.049	35,2%	76.815
2006.	33.606	90,6%	3.489	9,4%	37.095	***49,2%***	51.794	68,7%	23.635	31,3%	75.429
2007.	27.084	81,9%	5.979	18,1%	33.063	***38,1%***	58.030	66,9%	28.760	33,1%	86.790
2008.	34.263	81,2%	7.938	18,8%	42.201	***49,9%***	55.132	65,2%	29.450	34,8%	84.582
2009.	28.379	82,1%	6.194	17,9%	34.573	***41,9%***	53.970	65,4%	28.517	34,6%	82.487
Total	237.886	82,3%	51.049	17,7%	288.935	***44,0%***	416.731	63,5%	239.694	36,5%	656.425

Table 2. Felling from 2001 to 2009 – Forest Office Bjelovar

Along with a continuous growth of the allowable cut in this period (from approximately 600.000 m³ to approximately 700.000 m³), an increasing share of beech trees can also be seen in the average wood volume (from approximately 34 % to approximately 45 %). Similarly, it can be said that the share of the main felling has increased considerably (from approximately 60 % to almost 75 %) in an average wood volume of beech in the area of FABO Bjelovar. The survey of fellings performed in a limited research area (Forest Office Bjelovar, *Table 2*) show the same increasing trend of allowable cuts (from approximately 50.000 m³ to approximately 85.000 m³), increase of beech share in the total wood volume (from approximately 40 % to 50 %) and considerable increase of the main felling (even more than 90 %) in the average allowable cut of beech in the area of Forest Office Bjelovar (*Figure 4*).

These trends are the effect of the growing stock structure of the research area, disproportion of age classes, as well as some inconsistencies in determining the rotation of beech stands, and however they should be taken into account when planning the development of both forestry and wood-processing activities in the area of Bjelovar.

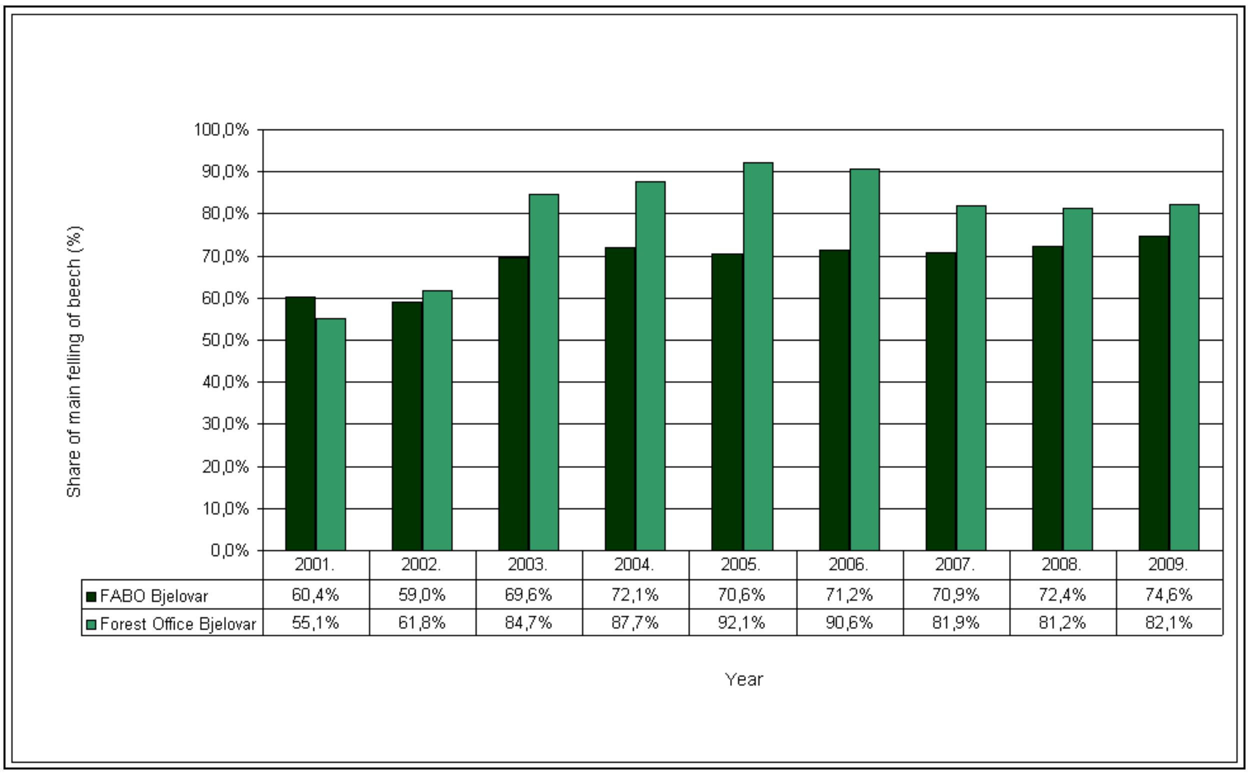


Fig. 4. Share of main felling in felled volume of beech from 2001 to 2009

2.2 Method of work

The age of felling sites ranged between 59 and 91 with thinning operations, between 94 and 110 with preparatory felling, between 100 and 112 with seeding felling and between 98 and 114 with final felling.

Type of felling															
Thinning				*Preparatory fellings*				*Seeding fellings*				*Final fellings*			
Forest block	Number of marked trees	Number of trees in the sample	%	Forest block	Number of marked trees	Number of trees in the sample	%	Forest block	Number of marked trees	Number of trees in the sample	%	Forest block	Number of marked trees	Number of trees in the sample	%
7c	292	60	20,5%	9a	1198	102	8,5%	11a	1667	177	10,6%	20d	394	46	11,7%
13a	665	65	9,8%	11a	683	78	11,4%	21a	2112	108	5,1%	21a	1201	74	6,2%
13b	285	51	17,9%	17a	865	91	10,5%	38a	1308	109	8,3%	42a	1239	118	9,5%
20e	569	66	11,6%	19b	490	58	11,8%	59c	409	41	10,0%	42c	876	104	11,9%
29a	368	46	12,5%	21a	1166	132	11,3%	83a	166	31	18,7%	59c	438	44	10,0%
29b	229	34	14,8%	38a	1164	102	8,8%	94b	650	76	11,7%	75a	547	55	10,1%
37a	631	83	13,2%	42a	456	63	13,8%	95b	439	64	14,6%	83a	445	42	9,4%
37c	335	48	14,3%	42c	394	42	10,7%	-	-	-	-	89b	145	23	15,9%
39b	368	56	15,2%	60a	862	97	11,3%	-	-	-	-	155f	953	57	6,0%
65b	164	24	14,6%	66a	577	64	11,1%	-	-	-	-	166c	135	20	14,8%
66b	163	31	19,0%	73a	888	100	11,3%	-	-	-	-	-	-	-	-
69b	515	67	13,0%	94b	343	54	15,7%	-	-	-	-	-	-	-	-
80b	46	17	37,0%	95b	306	42	13,7%	-	-	-	-	-	-	-	-
82a	159	49	30,8%	-	-	-	-	-	-	-	-	-	-	-	-
162a	371	45	12,1%	-	-	-	-	-	-	-	-	-	-	-	-
162c	282	45	16,0%	-	-	-	-	-	-	-	-	-	-	-	-
Total	5442	787	14,5%	Total	9392	1025	10,9%	Total	6751	606	9,0%	Total	6373	583	9,1%

Table 3. Distribution of model trees according to the standard HRN (1995)

The sample of model trees was formed by random selection of approximately 10 % of marked trees. Moving around the stand at predetermined azimuths, all marked beech trees found in the travel direction were included in the sample.

In the period 1997 to 2007, the field research involved a total of 3.776 model trees. Table 3 and 4 show the number of model trees by research compartment according to the type of cut and applied standard.

Vrsta sjeka - *Type of felling*															
Thinning				*Preparatory fellings*				*Seeding fellings*				*Final fellings*			
Forest block	Number of marked trees	Number of trees in the sample	%	Forest block	Number of marked trees	Number of trees in the sample	%	Forest block	Number of marked trees	Number of trees in the sample	%	Forest block	Number of marked trees	Number of trees in the sample	%
7c	292	59	20,2%	9a	1198	102	8,5%	11a	1667	174	10,4%	11a	721	76	10,5%
13a	665	65	9,8%	11a	683	78	11,4%	38a	1308	109	8,3%	38a	879	102	11,6%
13b	285	51	17,9%	17a	865	91	10,5%	59c	409	41	10,0%	42a	1239	118	9,5%
20e	569	66	11,6%	19b	490	58	11,8%	66a	953	138	14,5%	42c	876	104	11,9%
29a	368	46	12,5%	38a	1164	102	8,8%	73a	1077	155	14,4%	59c	438	44	10,0%
29b	229	34	14,8%	60a	862	97	11,3%	94b	650	76	11,7%	94b	711	133	18,7%
37a	631	83	13,2%	66a	577	64	11,1%	95b	439	64	14,6%	95b	378	68	18,0%
37c	335	48	14,3%	73a	888	100	11,3%	124a	1134	105	9,3%	-	-	-	-
39b	368	56	15,2%	94b	343	54	15,7%	-	-	-	-	-	-	-	-
65b	164	24	14,6%	95b	306	42	13,7%	-	-	-	-	-	-	-	-
66b	163	31	19,0%	-	-	-	-	-	-	-	-	-	-	-	-
69b	515	67	13,0%	-	-	-	-	-	-	-	-	-	-	-	-
80b	46	17	37,0%	-	-	-	-	-	-	-	-	-	-	-	-
82a	159	50	31,4%	-	-	-	-	-	-	-	-	-	-	-	-
162a	371	45	12,1%	-	-	-	-	-	-	-	-	-	-	-	-
162c	282	45	16,0%	-	-	-	-	-	-	-	-	-	-	-	-
Total	5442	787	14,5%	Total	7376	788	10,7%	Total	7637	862	11,3%	Total	5242	645	12,3%

Table 4. Distribution of model trees according to the standard HRN EN

Model trees were processed in accordance with the requirements of the *Croatian standards for forest harvesting products* (former JUS – standards of ex Yugoslavia) of 1995 (HRN D.B4.020, HRN D.B4.022, HRN D.B4.027, HRN D.B4.028, HRN D.B5.023), and «bucking simulation» was made on the same trees in accordance with the Croatian standard *Hardwood Round Timber – Qualitative classification, Part 1: Oak and beech HRN EN 1316-1:1999*. The faults of wood and processed round timber were measured in accordance with the terms of the standards HRN D.A0.101, HRN D.B0.022, and HRN EN 1309-2, HRN EN 1310, HRN EN 1311 and HRN EN 1315. Many other characteristics were also measured or assessed on model trees: diameter at breast height, tree height, trunk height, length of logs, trunk diameter, length of cut logs (1-m and longer), diameters of cut logs (1-m and longer), lengths and diameters of fuel wood up to 4 m in processing large fuel wood, length of waste wood, diameters of waste wood, bark thickness, false heartwood and described tree markings.

Out of the total number of model trees, 693 of them were processed and measured only in accordance with the requirements of the *Croatian standards for forest harvesting products* of 1995, on 2.308 trees the measurements and classification of technical roundwood were carried out in accordance with the requirements of both standards, while 775 model trees were measured and then technical roundwood was classified in accordance with the requirements of the Croatian standard *Hardwood Round Timber – Qualitative classification, Part 1: Oak and beech HRN EN 1316-1:1999*.

In this way the sample for the preparation of assortment tables in accordance with the requirements of Croatian standards for forest harvesting products of 1995 covered 3.001

model trees (*Table 3*). On the other hand, in accordance with the requirements of the Croatian standard HRN EN 1316-1:1999, assortment tables were prepared on the basis of the sample made of 3.082 model trees (*Table 4*).

By processing model trees of the sample in accordance with the requirements of the *Croatian standards for forest harvesting products of 1995*, 10.098 pieces of technical roundwood were produced, whose total volume without bark was 4.337 m^3. The total processed and used net volume of all sample trees according to the requirements of this standard was 7.469 m^3. By bucking the model trees according to the requirements of the Croatian standard *Hardwood Round Timber – Qualitative classification, Part 1: Oak and beech HRN EN 1316-1:1999* 13.507 pieces of technical roundwood were produced, whose total volume without bark was 6.010 m^3, and the total net volume of all sample trees, according to the requirements of the standard, was 8.931 m^3.

The occurrence and characteristics of false heartwood of beech trees were investigated with respect to diameter class of trees and type of cut. A sample of 787 trees was made in thinnings. In preparatory cuts 788 trees were processed, in seeding cuts 467 trees and in final cuts 266 trees, which makes a total of 2.308 trees (*Table 5*).

Beech false heartwood was measured on the front ends of the processed industrial roundwood of the pertaining tree in accordance with the procedure prescribed by the standard, i.e. minimum and maximum diameter of false heartwood is measured on the front ends, and the mean value is taken rounded to the nearest lower centimeter. The mean diameter of the relative front of the log is measured and determined in the same way. Measurements are carried out on both ends (fronts) of industrial roundwood. If false heartwood is only present on one front end of the log, at the other front end only the mean diameter is measured and determined. Absolute and percentage shares of false heartwood are expressed in wood volume of industrial roundwood in accordance with the standard, which prescribes Huber's formula for the calculation of log volume. Smalian's formula is used for the calculation of false heartwood volume in a log:

$$V_k = (g_1 + g_2)/2 * l \tag{1}$$

Where:
V_k = false heartwood volume,
g_1 = crosscut area of false heartwood at the thicker end of the log,
g_2 = crosscut area of false heartwood at the thinner end of the log,
l = log length.

This formula is known as the formula of two crosscuts, and it is used for accurate determination of the volume of an imperfect paraboloid (Pranjić & Lukić, 1997).

The volume of false heartwood was determined with some simplifications, which are conditioned by the procedure of felling and processing industrial roundwood. For a more accurate determination of false heartwood volume, it would be necessary to make more cross cuts or longitudinal cut in each piece of industrial roundwood, and this cannot be done for obvious reasons. Since a similar way of measuring false heartwood is applied in classifying wood assortments into quality classes and in trading with wood assortments, this way of measurement of false heartwood is acceptable. In the same way, the research of the share of false heartwood is restricted only to industrial roundwood, as in other wood assortments (parts of tree) it has almost no significance. Mathematical and statistical processing of data was carried out by use of computer program *Microsoft Excel 97*.

3. Results and discussion

Total percentage share of beech trees with false heartwood in individual types of cut increases from thinning, where it is 11,7 %, to final cut, where it is 84,6 % (*Table 5*).

Diameter class cm	Thinning		Preparatory felling		Seeding felling		Final felling	
	Number of trees							
	in sample	with false heartwood	in sample	with false heartwood	in sample	with false heartwood	in sample	with false heartwood
17,5	25	0	1	0	-	-	3	0
22,5	104	1	18	1	-	-	3	0
27,5	154	8	61	19	7	2	4	1
32,5	257	27	123	45	25	9	3	2
37,5	133	25	161	79	44	20	8	7
42,5	59	12	177	104	87	52	27	21
47,5	38	9	131	95	114	87	45	39
52,5	8	4	62	42	81	69	65	57
57,5	6	4	35	28	51	41	46	40
62,5	1	1	8	8	38	33	27	24
67,5	-	-	6	6	12	12	17	16
72,5	2	1	4	3	7	7	9	9
77,5	-	-	1	1	1	1	7	7
82,5	-	-	-	-	-	-	2	2
Total	787	92	788	431	467	333	266	225
Percentage	11,7%		54,7%		71,3%		84,6%	

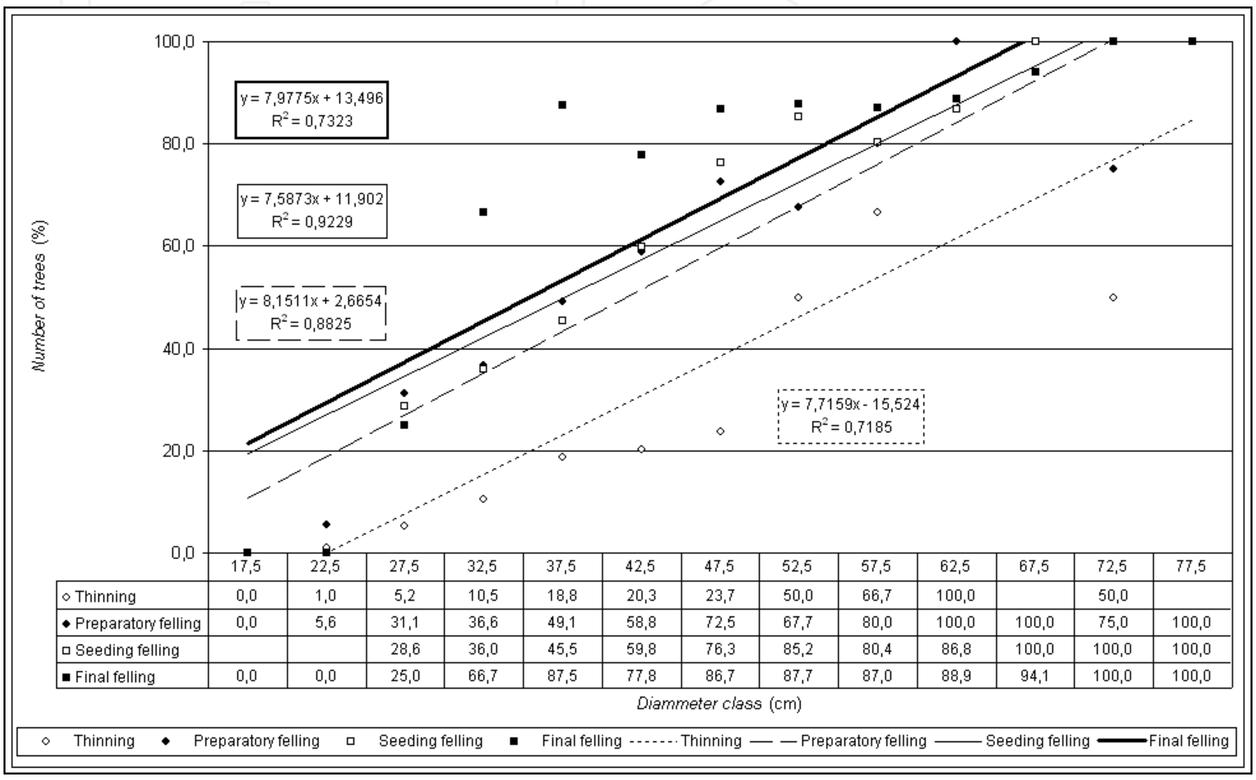
Table 5. Sample size and share of trees with false heartwood

The increase of total share of the number of trees with false heartwood by type of cut may be explained by the increase of the mean diameter at breast height (in terms of the increase of number of thicker trees in the sample) and stand age from thinning to final cut. The average age of the sample by type of cut is 76 years for thinnings, 104 years for preparatory cut, and for seeding and final cut the average age of the sample trees is 106 years.

As the distribution of diameters at breast height are different for individual types of cut, the number of trees with false heartwood was determined by diameter classes for each type of cut. Percentage share of beech trees with false heartwood by diameter classes and type of cut is shown in Table 5 and Figure 5. Diameter class with the highest number of trees with false heartwood increases from thinning to final cut, and diameter class in which more than half of trees with false heartwood may be expected decreases from thinning to final cut.

These results confirm past researches (Torelli 1984, 1994; Prka, 2003, 2005; Krpan at al., 2006) dealing with the origin of the process of formation of false heartwood at the age approximately ranging between 60 and 75. It can be concluded from these researches that the phenomenon of false heartwood does not considerably affect the structure of assortments of thinning stands, and however its impact on the structure of assortments of a shelterwood system (preparatory cut, seeding cut and final cut) cannot be absolutely excluded.

The increase of the number of trees with false heartwood within individual diameter classes from thinning to final cuts implies that the formation of false heartwood depends less on diameter at breast height, and more on stand age. Such distribution of trees in the sample with false heartwood, by type of cut and diameter class, fits fully into the latest researches of the cause of formation of false heartwood in beech trees (Torelli, 1984, 1994). Therefore, these results should be interpreted as the disruption of balance of water regime within the tree and dehydration of the central part of the tree trunk due to the disturbance of physiological balance in older trees.



	17,5	22,5	27,5	32,5	37,5	42,5	47,5	52,5	57,5	62,5	67,5	72,5	77,5
◇ Thinning	0,0	1,0	5,2	10,5	18,8	20,3	23,7	50,0	66,7	100,0		50,0	
◆ Preparatory felling	0,0	5,6	31,1	36,6	49,1	58,8	72,5	67,7	80,0	100,0	100,0	75,0	100,0
□ Seeding felling			28,6	36,0	45,5	59,8	76,3	85,2	80,4	86,8	100,0	100,0	100,0
■ Final felling	0,0	0,0	25,0	66,7	87,5	77,8	86,7	87,7	87,0	88,9	94,1	100,0	100,0

Fig. 5. Share of number of trees with false heartwood

The length of industrial roundwood made from the tree affected by the process of formation of false heartwood was measured during the measurement of industrial roundwood. It represents total length of industrial roundwood made from the tree where false heartwood appears at least at one front end (cross cut) of the log during bucking and cross-cutting of industrial roundwood in accordance with Croatian Standards. According to the way of measurement, it can be seen that the actual longitudinal presence of false heartwood in the tree, i.e. in industrial roundwood, remains partly unknown for understandable reasons. Total length of false heartwood in industrial roundwood is surely somewhat smaller than the length measured in this way (*Table 6, Figure 6*). On the other hand, false heartwood may remain hidden with some logs, i.e. it must not necessarily appear at the front ends of logs. For these reasons, data obtained in this way have only an approximate value.

Table 6 and Figure 6 present the data on mean (average) value of length of industrial roundwood affected by false heartwood by type of cut and diameter class. As the decision on the place of the trunk cut in the production of logs is made based on external characteristics, data on the length of industrial roundwood affected by the process of formation of false heartwood collected in this way have a certain operating value.

Diameter class cm	Thinning	Preparatory felling	Seeding felling	Final felling
	Mean lenght of roundwood with false heartwood			
	m			
22,5	2,35	5,32	-	-
27,5	5,96	5,60	3,92	3,73
32,5	7,23	8,97	7,88	8,65
37,5	10,02	10,11	11,17	14,93
42,5	10,50	12,16	12,14	13,33
47,5	7,16	11,84	13,35	15,61
52,5	5,44	13,36	13,55	16,70
57,5	6,51	12,92	13,91	15,83
62,5	4,16	12,11	14,04	16,61
67,5	-	14,69	13,64	15,31
72,5	3,71	7,20	16,84	14,62
77,5	-	22,47	17,30	16,01
82,5	-	-	-	13,78

Table 6. Mean length of false heartwood in industrial roundwood of beech trees

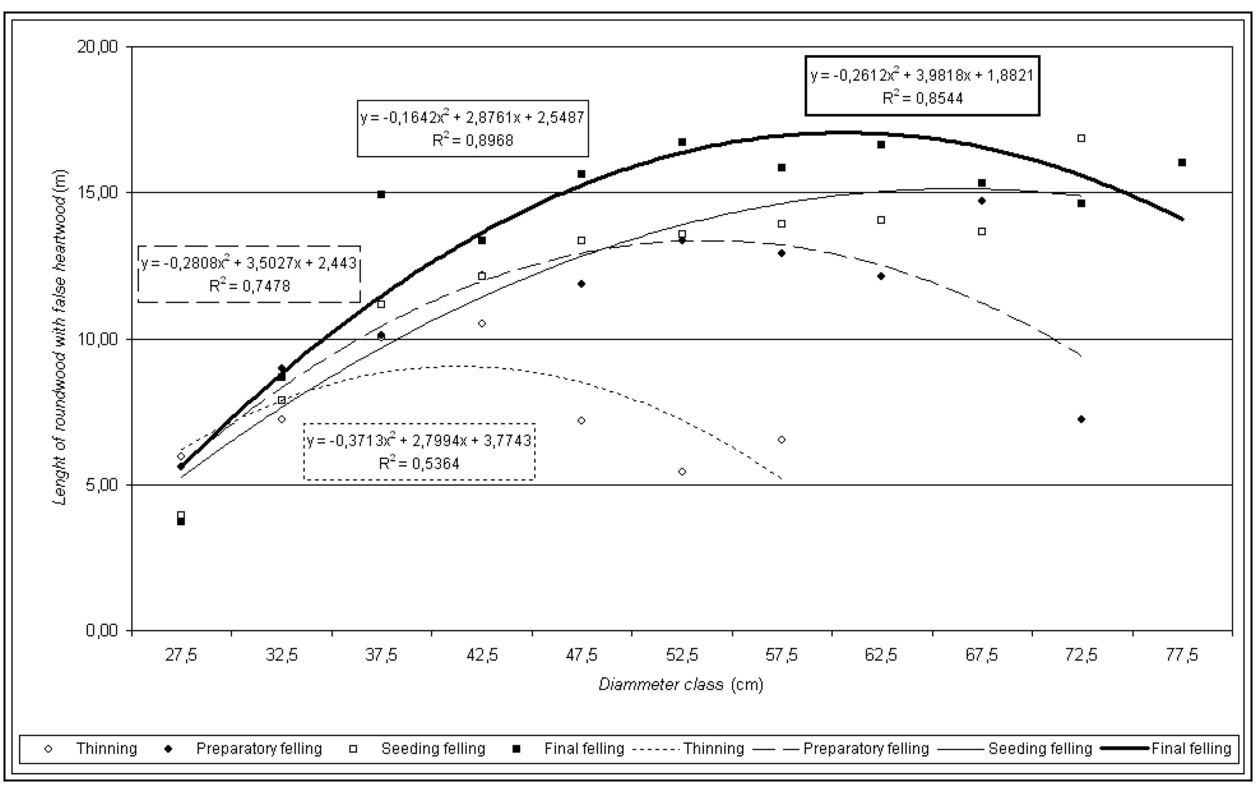


Fig. 6. Mean length of industrial roundwood with false heartwood

Mean values of the length of false heartwood and the trend line are presented in Figure 6 only for diameter classes containing three or more trees of diameter classes with false heartwood. The increasing trend of the length of industrial roundwood with false heartwood can clearly be seen from thinnings to final cut. The reasons of such trend may be explained by the above stated factors that cause the formation of false heartwood. This fact affects the absolute value of false heartwood volume in the volume of industrial roundwood of a certain type of cut. Lower values of the average lengths of false heartwood in the volume of industrial roundwood in larger diameter classes of thinnings (and even in preparatory cut) imply that the diameter at breast height is not a decisive factor in the formation of false heartwood.

The data presented in Table 7 and Figure 8 show the increase of the average absolute values of the volume of false heartwood in industrial roundwood by diameter classes and from thinnings to final cut. The lowest mean values were recorded with trees with false heartwood in thinnings and then trees in preparatory cut. With trees in preparatory cut the increase of heartwood volume of industrial roundwood of larger diameter classes is not as significant as with trees in seeding and final cut. In this respect, trees with false heartwood in seeding and final cut show very close values and an almost linear dependence.

Mean percentage values of the share of false heartwood volume of industrial roundwood, presented in Table 7 and Figure 7, show considerably different characteristics, almost contrary to absolute values. The more or less regular increase of mean percentage values of false heartwood volume in the volume of industrial roundwood from thinning to final cut is a common feature with absolute values of false heartwood volume in the volume of industrial roundwood.

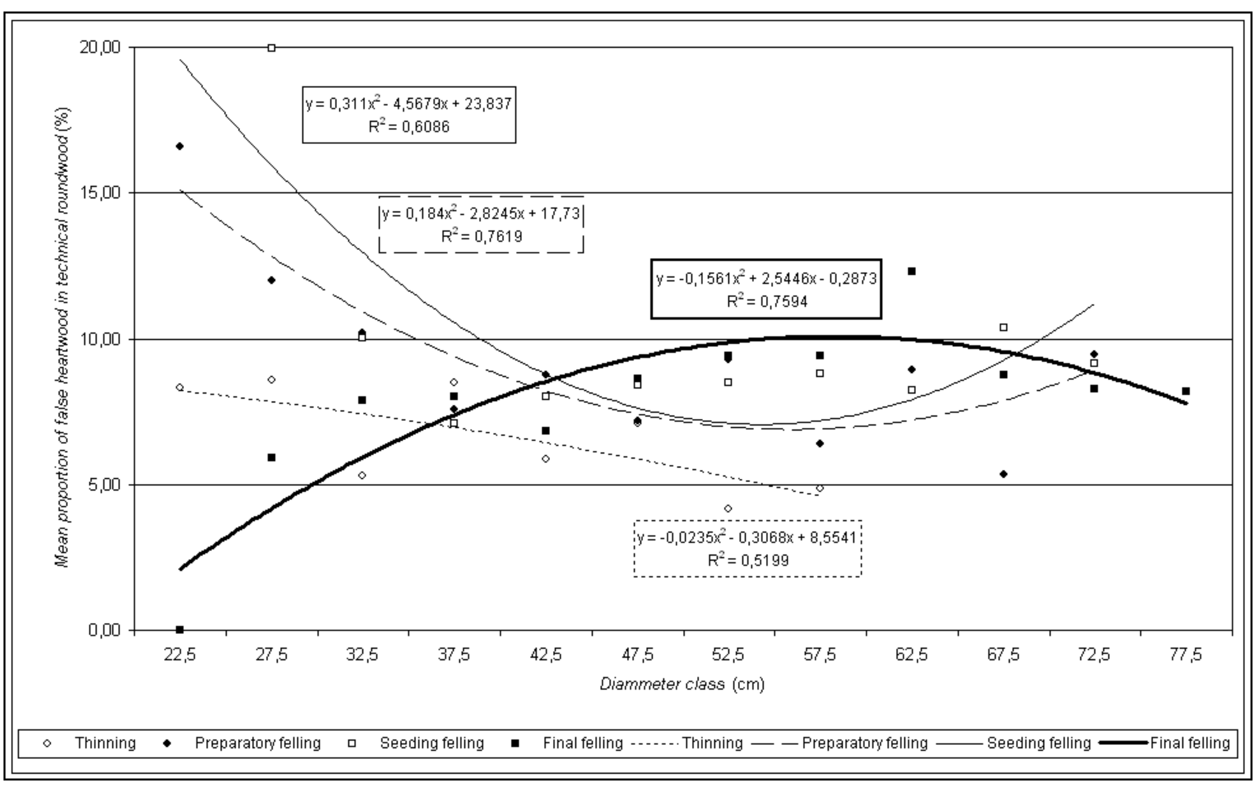


Fig. 7. Mean share of false heartwood in the volume of industrial roundwood of beech trees

A weaker correlation between the mean absolute values of false heartwood volume in the volume of industrial roundwood and the trend line is the effect of a considerably higher range of stand age of thinnings, where the measurements were carried out. This age ranges between 50 and 91 in thinnings, between 96 and 111 in preparatory cuts, between 101 and 112 in seeding cuts, while in final cuts it ranges between 98 and 112. As the above mentioned researches outlined the older age of beech trees (from 60 to 90 years) as the beginning of intensive formation of false heartwood, the sample of trees from thinning stands is the least homogenous in that respect (stand age). Mean values of absolute volume of false heartwood by diameter classes in seeding and final cuts show a great similarity as well as strong correlation, as well as trend lines of these types of cut.

Diameter class	Thinning		Preparatory felling		Seeding felling		Final felling	
	Proportion of heartwood							
cm	m^3	%	m^3	%	m^3	%	m^3	%
22,5	0,01	8,31	0,04	16,58	-	-	-	-
27,5	0,03	8,56	0,04	12,00	0,06	19,94	0,01	5,92
32,5	0,02	5,30	0,06	10,20	0,06	10,03	0,05	7,88
37,5	0,06	8,49	0,08	7,59	0,09	7,11	0,11	8,01
42,5	0,08	5,85	0,12	8,74	0,13	8,00	0,12	6,81
47,5	0,08	7,08	0,12	7,19	0,17	8,39	0,19	8,61
52,5	0,03	4,14	0,22	9,28	0,21	8,48	0,25	9,43
57,5	0,08	4,86	0,19	6,38	0,23	8,79	0,28	9,41
62,5	0,06	3,25	0,26	8,93	0,29	8,24	0,43	12,31
67,5	-	-	0,20	5,36	0,36	10,38	0,35	8,75
72,5	0,19	4,03	0,23	9,47	0,37	9,14	0,40	8,27
77,5	-	-	-	-	0,37	5,67	0,43	8,20
82,5	-	-	-	-	-	-	0,27	4,47

Table 7. Volume of false heartwood in industrial roundwood of beech trees

For all types of cut, except for final cut, the percentage shares of false heartwood volume in the volume of industrial roundwood show a decreasing trend by diameter classes. This trend may be explained by the fact that absolute volume of industrial roundwood increases with the increase of the diameter at breast height, and consequently the percentage share of industrial roundwood with false heartwood decreases. On the other hand, trees with smaller diameter at breast height with false heartwood show larger shares of false heartwood in the volume of industrial roundwood due to a lower share of volume of industrial roundwood. This all leads to a more or less decreasing trend of percentage shares of false heartwood in the volume of industrial roundwood. In this respect mean values of thinning stands show a linear correlation.

False heartwood affects most significantly the structure of beech assortments of the highest quality in terms of lowering their quality and market value. International (EU) standards allow up to 20 % of sound false heartwood in A quality class and up to 30 % in B quality class, while there are no limits for C and D classes. Star-like heartwood is not allowed in A class, in B class it may be present up to 10 %, and in C class up to 40 %, while in D class there are no limits. The influence of false heartwood on the quality and value of wood assortments can be primarily determined through the share of sub-classes in the classes of the highest quality (A and B class) of beech industrial roundwood. The Croatian standard

HRN EN 1316-1:1999 for beech provides the possibility of application of sub-class *A-red (A-s) and B-red (B-s)* depending on trade agreements. In these sub-classes, unlimited presence (up to 100 %) of homogenous and sound false heartwood (red heartwood) is allowed. In other words, industrial roundwood is classified into these sub-classes (A-s and B-s) if by its dimensions and other criteria it meets the requirements of A and B class, and however contains an excessive share of homogenous and sound false heartwood.

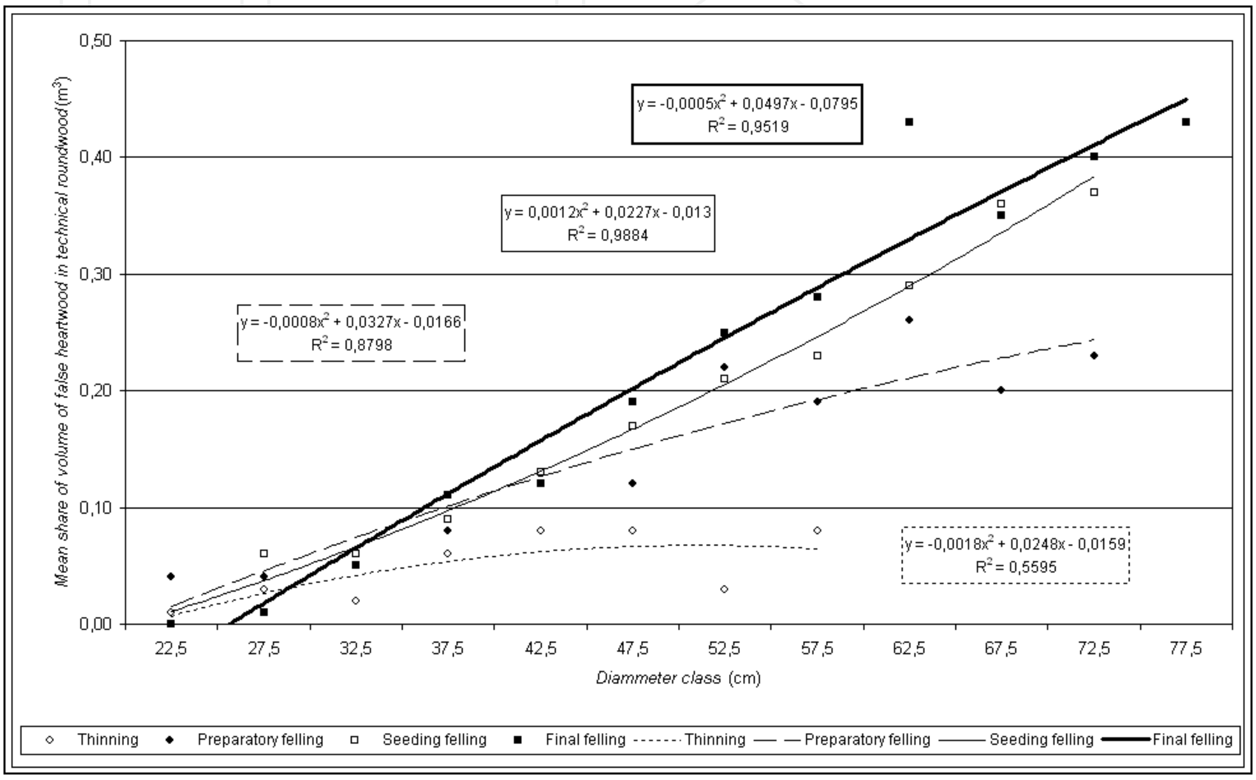


Fig. 8. Volume of false heartwood in industrial roundwood of beech trees

As the appearance, development and share of false heartwood in thinnings and preparatory cuts is not very significant, which was determined by previous researches (Prka, 2003, 2005, Krpan et al., 2006), these sub-classes of wood assortments of the highest quality have no significant effect on the assortment structure of thinnings and preparatory cuts. The presence of these sub-classes was investigated on 519 trees of seeding and final cut. Table 8 shows the percentage share of sub-class A-s and B-s according to number of pieces of industrial roundwood and share in the volume of industrial roundwood of quality class A and B. A-s logs account, on average, for 14,36 % in total volume of A class logs, and B-s logs account for 15,27 % in total volume of B class logs.

Type of felling	Forest block	A		A-s				B		B-s			
		Number of roundwood	Volume of roundwood m^3	Number of roundwood	Volume of roundwood m^3	Share in number %	Share in volume %	Number of roundwood	Volume of roundwood m^3	Number of roundwood	Volume of roundwood m^3	Share in number %	Share in volume %
Seeding	66a	47	32,54	4	2,99	8,51	9,20	122	79,79	8	6,14	6,56	7,70
Final	11a	25	21,61	6	5,31	24,00	24,59	76	62,56	7	7,48	9,21	11,06
Final	38a	69	79,45	10	12,70	14,49	15,98	108	103,4	18	19,80	16,67	19,14
Final	94b	82	104,8	14	19,47	17,07	18,58	140	141,6	24	33,78	17,14	23,86
Final	95b	47	65,78	3	3,22	6,38	4,90	70	67,33	2	2,25	2,86	3,34
Total		270	304,18	37	43,69	13,70	14,36	516	454,68	59	69,45	11,43	15,27

Table 8. Share of logs of A-s and B-s in A and B class according to number and volume

Obstacles related to processing, precision and practical application of assortment tables, and to the increase of reliability of business decision-making in planning the assortment structure of managed beech stands, usually arise out of the following facts:

- quality of trees and of the whole stand is the result of continuing impact of different abiotic and biotic factors,
- total volume of the stand cannot be used as the basis for planning felling, processing and extracting, and most of all not as the basis for calculating the financial income,
- usable volume of trees and stands varies in a wide range of values from approximately 30 % to 80 % (or more) compared to the total volume,
- distribution of wood assortments in individual trees is conditioned by diversity of their habitus and occurrence of faults on and in the tree,
- occurrence of faults, their size and number on and in the tree, is of random character and it cannot be correlated with measurable tree parameters,
- wood assortments of the same quality are not always produced from trees with the same dimensions and equal quality characteristics,
- there are differences between the classification of wood assortments in different countries, and the classification standards are subject to changes with time,
- in determining the quality of wood assortments, apart from measurable parameters, there is also a series of subjective assessments,
- analysis of the structure of wood assortments achieved in the process of wood production provides no possibility to make final conclusions primarily because there is no correlation between breast-height diameters of individual trees and the produced assortment structure, and due to the effects of the market and other relationships on the production process.
- assortment structure of managed stands is partly the result of man's impact, and such impacts have not been sufficiently researched nor recognized.

Due to the above reasons, the method for determining the assortment structure that would be relatively quick, simple and accurate is still to be found. In all methods used so far, model trees were used for determining the total volume and volume assortments by sectioning of standing and felled trees.

Tables showing shares of wood assortments determined in accordance with the *Croatian standards on forest harvesting products of 1995* and in accordance with the Croatian standard *HRN EN 1316-1:1999 Hardwood Round Timber – Qualitative classification, Part 1: Oak and beech* were developed separately for thinning and preparatory felling, and separately for seeding and final felling. This was done due to numerous reasons stated and explained above, and due to results of researches published before. The reasons for separating thinning and preparatory felling trees into special assortment tables are as follows:

- thinning sites and preparatory felling sites have an exceptionally high share of undamaged trees of abnormal growth and generally a higher percentage share of trees with negative impact on assortment structure of the felling site in the total number of marked trees compared to seeding and final felling (Prka, 2005, 2006a),
- marked trees of thinning and preparatory felling have on average a lower trunk height and consequently a lower share of technical roundwood is made of tree trunks compared to seeding and final felling (Prka, 2005, 2006b),

- validation analysis of trees by type of cut shows that thinning and preparatory felling trees have lower index values compared to trees from final and seeding felling (Prka, 2003a, 2005),
- total percentage share of technical roundwood in the net volume of trees is lower with thinning sites compared to other types of cut and it increases from thinning towards final felling (Prka, 2005),
- analysis of total deviations of percentage shares of wood assortments of the highest quality from the plan (analysis carried out in a three-year period in the research area) shows that tables of wood assortments, currently in use, overestimate the percentage share of veneer logs and peeling logs in thinning and preparatory felling sites (Prka, 2003a),
- in thinning and preparatory felling, the occurrence of trees with the highest quality assortments of technical roundwood is less probable (F - veneer and L – peeling logs – A and B quality class) and consequently the percentage share of wood assortments of the highest quality in the volume of large wood is also smaller compared to trees of seeding and final felling (Prka, 2005, 2008, Prka & Krpan, 2007),
- occurrence of false heartwood is not significant in felling sites up to the age of approximately 90 years due to the fact that in older thinnings around 15 % of trees with false heartwood may be expected. On the other hand in felling sites aged from 100 to 110 false heartwood is quite significant as it can be expected with more than 50 % of marked trees (Prka, 2003b, 2005, Prka et al., 2009, Krpan et al., 2006),
- number of trees with false heartwood increases from thinning towards final felling, as well as the length of technical roundwood with false heartwood and shares of technical roundwood affected by false heartwood (Prka, 2005, Prka et al., 2009, Krpan et al., 2006),
- seeding and final felling compared to thinning and preparatory felling show higher shares of the highest quality wood assortments depending on the diameter class by: approximately 8 to 14 % (veneer logs and peeling logs) with the application of the *Croatian Standards for Forest Harvesting Products (1995)*, and approximately 11 to 13 % (A and B – quality class) with the application of Croatian standard *HRN EN 1316-1:1999 Hardwood Round Timber – Qualitative classification, Part 1: Oak and beech* (Prka, 2005, 2008a, Prka & Krpan 2007),
- percentage shares of wood assortments by quality classes retain the same ratios (of course not the same percentage shares) regardless of the applied system of standards (Prka, 2005, 2008a, Prka & Poršinsky, 2009).

All the above reasons for dividing the sample of model trees and differences between these two groups of felling types are the result of our decisions. A common feature of the marked trees in thinning and preparatory felling is that they are chosen by selection criteria, which becomes irrelevant when the preparatory felling is completed because the key role in selecting trees for felling is then played by seeding, state of young growth and space distribution of the remaining trees. The share of wood assortments by individual types of felling is largely the result of our decisions in selecting trees for felling, based on which the objectives and guidelines of stand management are implemented.

In short, when determining the mathematical model for the development of volume of wood assortments, it should be taken into account that it depends on natural laws of development, which are not well known and which are affected during rotation by changing directly the stand structure (by silvicultural activities and natural regeneration through preparatory and finishing felling) and by applying the system of standards and trade conventions, both changeable with time.

In implementing sustainable management of beech forests, the factors that affect the assortment structure of even-aged beech felling sites, determined by this research, are as follows:

- selection criteria of trees for felling (marked) beech trees by which the prescribed type of cut is performed in managing natural beech stands,
- reached technological level of wood production which involves both technical equipment and development of forest infrastructure, as well as professional competence of all participants in wood production and the whole forest management,
- faults of beech wood formed as the consequence of natural development of beech stands and man's impact, among which false heartwood is the most conspicuous,
- procedures with beech technical roundwood during and after operations of wood production and the prescribed ways of measuring and calculating the volume of beech roundwood as well as their operational application,
- market relationships, besides demand and supply, also greatly conditioned by the development of capacities for processing beech into products such as wood products and other products (energy and similar),
- reached level of knowledge of the possibility to achieve the quantity and quality of beech from natural beech stands, and operational application of such knowledge.

4. Conclusion

False heartwood of beech affects considerably the quality of wood assortments in beech felling sites. The impact of individual types of cut on the assortment structure of beech felling sites will primarily depend on the number of trees affected by the process of development of false heartwood. This number ranges between 11,7 % of trees in thinnings, more than 54,7 % of trees in preparatory cut and 71,3 % in seeding cut and up to 84,6 % of trees with false heartwood in final cut. Hence, with the increase of the diameter at breast height of the tree, the number of tree with false heartwood increases, as well as the length of industrial roundwood with false heartwood and the volume of red heartwood in the volume of industrial roundwood of the tree. Contrary to that, the percentage share of false heartwood in the volume of industrial roundwood decreases with the increase of diameter at breast height of the tree, except in final cut.

The appearance of false heartwood has no special significance in planning assortment structures in thinnings of even-aged beech stands, considering the fact that about 10 % to 15 % of trees with false heartwood may be expected in older thinnings. On the other hand, in planning assortment structures of preparatory, seeding and final cuts, the appearance of false heartwood may be expected in approximately 55 % to 85 % of marked trees. In seeding and final cuts approximately 15 % of the volume of wood assortments of the highest quality

(A and B quality class) has an excessive share of sound false heartwood in A and B quality class. With respect to the volume of large wood, the share of A-s sub-class, depending on the diameter class, ranges between 0,3 and 2 %, and the share of B-s quality class between 1,1 and 3,2 % of the volume of large wood.

The distribution of trees in the sample with false heartwood, by type of cut and diameter class, fits fully into the latest researches of the cause of formation of false heartwood in beech trees (Torelli, 1984, 1994). Therefore, these results should be interpreted as the disruption of balance of water regime within the tree and dehydration of the central part of the tree trunk due to the disturbance of physiological balance in older trees. In investigating assortment structure of beech felling sites, the frequency of occurrence and volume of false heartwood in main fellings is the factor that affects considerably the quality of industrial roundwood.

Also, there are many other factors affecting the assortment structure of managed beech stands, and their impact is very complex. Some of these factors affect directly, and others indirectly, the possibility of achieving the quality of beech forest assortments. These factors are partly the result of natural laws of development of beech stands and trees, and partly the result of human and environmental impact. Some of these factors are objective and their impact cannot be avoided, while others are of a subjective nature and influence.

The effects on quantity and quality of beech forest assortments of even-aged management stands that can be achieved by performing a certain type of cut can be operationally related to:

- abiotic factors shown through climate, edaphic and orographic phenomena, and having a continuous and interdependent impact, whose adverse effect can usually be seen in extreme values,
- biotic factors mostly shown in human activities (beneficial and harmful) although there are also others (bacteria, fungi, insects, wild game, etc.),
- historic development of beech stand management, i.e. development of the organization of forestry science, operating practice and education of forestry staff, which finally resulted in the current state and potential of managed beech stands,
- comprehensive management of beech stands and organization of forestry economic activities, as well as position of these activities in a wider business (social) environment,
- achieved technological level of wood production that provides optimal implementation of operations in the production of beech forest assortments, including technical equipment and professional competence of all participants in the process of wood production,
- wood faults whose occurrence and number, although they are of random nature, can be partly affected (as well as total habitus of beech trees) by beech stand management,
- rotation of even-aged beech stands, i.e. determination of time of felling of individual trees, which is particularly emphasized with this species due to the occurrence and pattern of development of false heartwood,

- bucking of beech technical roundwood, precision of measurement and consistent use of applicable regulations (standards) for the classification of forest wood assortments into quality class,
- research of these issues and application of research results with the aim of developing more precise and operationally more applicable assortment tables, and more objective planning and control of production of beech assortments,
- development (changes) of standards for the classification of forest assortments into quality classes, technology of production and use of beech forest assortments, as well as development of market relationships.

Production possibilities of management stands are not without limits. From our point of view (the view of the currently active forestry staff), they are more or less permanent. We are not in a position to make, in a short term, a considerable increase (if any) of the production of natural stands. We can suggest where (on which trees) the increment of wood volume will be accumulated and when it should be sold. By our short-term operations (silvicutural operations, wood production) we can only make optimal use of and preserve the production possibilities of the stand, and leave to future generations stable stands of a potentially higher quality.

By managing beech stands, meeting scientific and professional requirements, the said impacts on the quantity and quality of forest wood assortments may be directed to a certain extent, through the life cycle, to the target production. With the application of tending procedures and regeneration of beech stands, with passing of time, the value of the stand and wood assortments produced by individual type of cut increases. In biological (physiological) and economic context, the development of false heartwood with beech trees has an opposite trend, and the positive selection of trees that carry the development of the stand and natural regeneration provide the transfer of the best properties to future generations. This is a compromise that must be accepted by proper management and determination of harvesting rotation of beech stands.

The economic development of each region in the Republic of Croatia should be based on its natural resources. Forests, forestry and wood production are significant natural (and economic) resources of the region of Bjelovar and Bjelovar and Bilogora County, where the share of beech and beech forest assortments are of the highest significance. Unfortunately, during the last turbulent 20 years, wood production in this area has been losing the significance expected based on traditional and natural resources. This has a negative effect both on forestry and the development of this region as a whole. The reasons are many, and one of the most important is the lack of concept of forestry and wood industry development based on a comprehensive understanding of the ways of using forest wood assortments applied before and on objective planning of the achievable assortment structure of the allowable cut in this area in future. Although such analyses are part of decision making at a strategic level, in the Republic of Croatia they have not been implemented satisfactorily and by using the relevant (true, accurate) data. In the past, the results of such unreliable and incomplete analyses were used by specific circles for the purpose of retaining favored market positions, rather than for the purpose of long-term development of forestry, wood industry and economy as a whole. At the end of 2008, negative global economic trends (recession) started in this segment of Croatian economy, too, and most past omissions have been disclosed and the position of economic entities still dealing with forestry and wood production has become even more difficult.

Regardless of the degree of (de)centralization of management of these resources, the profit of forestry activities, whose duration corresponds to the duration "of water droplets on a hot stove", should not be the basic interest of the state - the owner of most forests and enterprises that manage them. It is not hard to conclude that the permanent interest of the owner (society as a whole - state) should be to employ as many people as possible based on sustainable and economic principles of forestry, and use (process) forest products, especially in regions having such resources.

The use of beech-wood, especially processing of beech technical roundwood, is specific in the area of Bjelovar due to its high share in the allowable cut, as well as somewhat higher processing requirements and lower profits that can be made right after the primary processing of beech logs, and after a low degree of wood processing. Besides, compared to wood assortments of some other species, the market demand of beech assortments is less stable. Therefore, beech technical roundwood (e.g. compared to technical roundwood of pedunculate oak) is often treated as necessary evil in commercial and processing context. On the other hand, the quality of beech-wood and its share in the allowable cut of this area show that such attitude should be changed. This requires considerable changes in the approach to this problem of all involved in this segment of Croatian economy, and especially those connected in any way with this area. As it is highly probable that this region will become a "raw material basis" due to further decay of wood processing capacities, unfortunately this is not a matter of wishes or possibilities, but rather a necessity requiring urgent action. To put it mildly, it is highly unreasonable to expect solutions from those who have won (and are still fighting for) their position in the global market.

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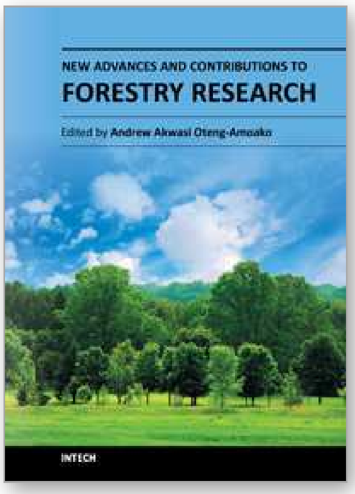

New Advances and Contributions to Forestry Research

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New Advances and Contributions to Forestry Research consists of 14 chapters divided into three sections and is authored by 48 researchers from 16 countries and all five continents. Section Whither the Use of Forest Resources, authored by 16 researchers, describes negative and positive practices in forestry. Forest is a complex habitat for man, animals, insects and micro-organisms and their activities may impact positively or negatively on the forest. This complex relationship is explained in the section Forest and Organisms Interactions, consisting of contributions made by six researchers. Development of tree plantations has been man’s response to forest degradation and deforestation caused by human, animals and natural disasters. Plantations of beech, spruce, Eucalyptus and other species are described in the last section, Amelioration of Dwindling Forest Resources Through Plantation Development, a section consisting of five papers authored by 20 researchers. New Advances and Contributions to Forestry Research will appeal to forest scientists, researchers and allied professionals. It will be of interest to those who care about forest and who subscribe to the adage that the last tree dies with the last man on our planet. I recommend it to you; enjoy reading it, save the forest and save life!