Original scientific paper

Natural composition of tree species as a basis for model development of stumpage price

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Abstract – Nacrtak

Model development and use play a significant role in research and forest management of Slovenian forests. As co-natural and sustainable forest management is traditional, it is essential to rely on available knowledge of the composition of natural plant associations. This paper describes the need for stumpage price modelling, and the basic concept of developing models which can behave dynamically as forest structure approaches the final goal – tree composition close to nature. The main plant associations in Slovenia and their characteristic tree structure represent the so called model goal. Input data are taken from forest inventory base and are compared with the model goal. The difference between the model and true tree structure together with growth and other variables gives the intensity and structure of prescribed annual cut and consequently the value of wood assortments. The model produced several possible scenarios for the next decades, and this has already proved to be a good basis for decision making.

Keywords: *plant associations, stumpage price, forest management, model*

1. Introduction – *Uvod*

Forest inventory base in Slovenia comprises a vast collection of data, which is barely used for more complex analyses. On the other hand there is vast interest in long term forecasts at different levels. The greatest interest is shown by some forest companies and large forest owners. The Forest Act prescribes co-natural, sustainable and multifunctional forest management, which should also support biodiversity and have respect for the social aspect of forests. Obviously the knowledge of the natural state of the forest vegetation is essential in searching the best alternatives of the future forest development.

The picture of the tree composition of natural forest vegetation association in the past can only be got with two groups of variables. In the first group intensive human-related factors are found with the related erosion processes. At the beginning these factors had been connected with existential needs of settlers, but later the commercial use of forest became more important. The demands have also been influenced by today's silvicultural concepts. The second group of factors is presented by natural ability of forest regeneration, which has been restored in dependence on the natural forest plant association, and that still happens in recent succession. During this progressive process not all of the past stand structures have been reconstructed, and the differences in their age structure still remain visible. Changed age structures strongly influence the share of tree species with shorter life span.

The central part of Slovenia has always been heavily covered with the natural forest. Regeneration of the forest is very strong, and within the natural vegetation associations, also very fast. The mosaic of the stand development phases can indicate their succession stages, thus making possible the following of their whole recent succession. The small-scale ownership structure of Slovenian forest have contributed a lot to the knowledge about succession stages, as small parts of the forest mix together with known historical development.

Studies of potential forest vegetation have always been based on the knowledge of their succession. However, the definition of single association has been based on studies of the most undisturbed forest stands, which were the closest to their original natural structure and form (Košir 1979, Košir 1992, Košir 1994). Today these forests belong to commercial forests of different silvicultural concepts, but mostly in optimal development phases. Such studies can provide very limited knowledge about their further development toward the original virgin forest forms, but as forests are managed with essentially shortened natural cyclic time rotation – one half or even less – the figures of the characteristic natural composition of potential forest vegetation become even more important. The results of such studies are an excellent base for the estimate of natural tree structure of forest vegetation associations in present silvicultural forms.

2. The need for modeling – *Potreba za modeliranjem*

Forest management is closely and traditionally related to natural development of forest stands. Despite many man-made changes, the potential state of forest has recently been the most important basis for making short and long term decisions. For many years, traditional methods of forest inventory had been sufficient for obtaining data needed for making decisions about allowed annual cut, intensity and frequency of thinnings, the beginning of regeneration and many other specific measures in the forest. These methods are not sufficient for developing projections of forest development for a longer period of time and accordingly for providing the necessary investments in the forest as the basis for technologic solutions of prescribed measures. The revenues from the forest and stumpage values on a larger time scale can only be computed with the help of an appropriate model. There are yet many other possibilities which are available through model employment and, however, they are not within the scope of this paper (Krč 1995, Krč 1999b).

The number of variables which have significant influence on making decisions is also increasing, as there is a growing demand for including different forest functions into our decisions. The need to build tools for decision making is therefore very urgent, and it demands the skill of computer programming, understanding the forest management general demands, technological knowledge and an excellent knowledge of the potential natural state of forests (Košir 1997).

3. Methods – *Metode*

The basic assumption was that the model could be used for describing nondeterministic system with many stochastic variables, and it triggered the beginning of the research. Such work demands the involvement of the experts from different fields of forest science, but the expected result is worth the effort. Complexity, flexibility and dynamics are the main characteristics to be met during the model development. Dynamics plays a special role as it depends on the input status of the chosen variables, final goal to be achieved and procedures to be applied for achieving the goal.

In the Slovenian co-natural forest management the final long-term goal is determined by the composition of tree species which is close to the potential natural state of forest stand (Košir 1975, Košir 1976). Plant associations that are the most important from the forest management point of view, as well as some others that cover larger areas in the Submediterranean part of Slovenia or have very narrow ecological scope, are presented in Appendix 1.

In accordance with the task, this paper presents the potential tree structure of plant associations with the stress on the carriers of the growing stock. Tree species, which are minorities with similar growth and life span, are summoned in separate groups. The group of high value broadleaf trees that are common in mountainous terrain consists of the following species: *Acer pseudoplatanus* L., *Acer platanoides* L., *Ulmus glabra* Huds., *Fraxinus excelsior* L. and rarely *Tilia platyphyllos* Scop. In the forests of flatland and hills we can find in the same group: *Ulmus laevis* Pallas, *Fraxinus oxycarpa* Willd. (*F. angustifolia*), *Alnus glutinosa* (L.) Gaertn. and *Tilia cordata* Mill. In the group of hard broadleaf species of the low land forest, there are: *Carpinus betulus* L. and beside also *Acer campestre* L., *Prunus avium* L. and *Sorbus torminalis* (L.) Cr. On slightly higher altitudes the following species in the same group prevail: *Ostrya carpinifolia* Scop., *Sorbus aria* (L.) Cr., *Quercus cerris* L. and *Sorbus aucuparia* L. A separate group of soft broadleaf trees, which appear as followers from lowland to the lower mountains, consists of the following species: *Popupus tremula* L., *Populus alba* L., *Salix alba* L., *Betula pendula* Roth. and *Alnus incana* (L.) Moench. The share of the most important tree species in the growing stock is defined separately. These species are: *Picea abies* (L.) Karst., *Abies alba* Mill., *Larix decidua* Mill., *Pinus sylvestris* L., *Pinus nigra* Arnold, *Fagus sylvatica* L., *Quercus robur* L., *Quercus petraea* (Matt.) Liebl. in *Acer pseudoplatanus* L.

The tree species structure, which is the closest to the structure of some associations in the neighbouring countries is that of prealpine beech forest and mixed forests of silver fir and beech. There are, however, significant differences in the structure of tree species shown in Appendix 1 and similar associations in Switzerland and Austria (Zukrigel 1973, Mucina et al. 1993, Oberdorfer 1992a, Oberdorfer 1992b, Ellenberg 1996). Let us look at some examples. In the Slovenian mixed silver fir–beech forests on limestone the share of spruce is significantly lower, the

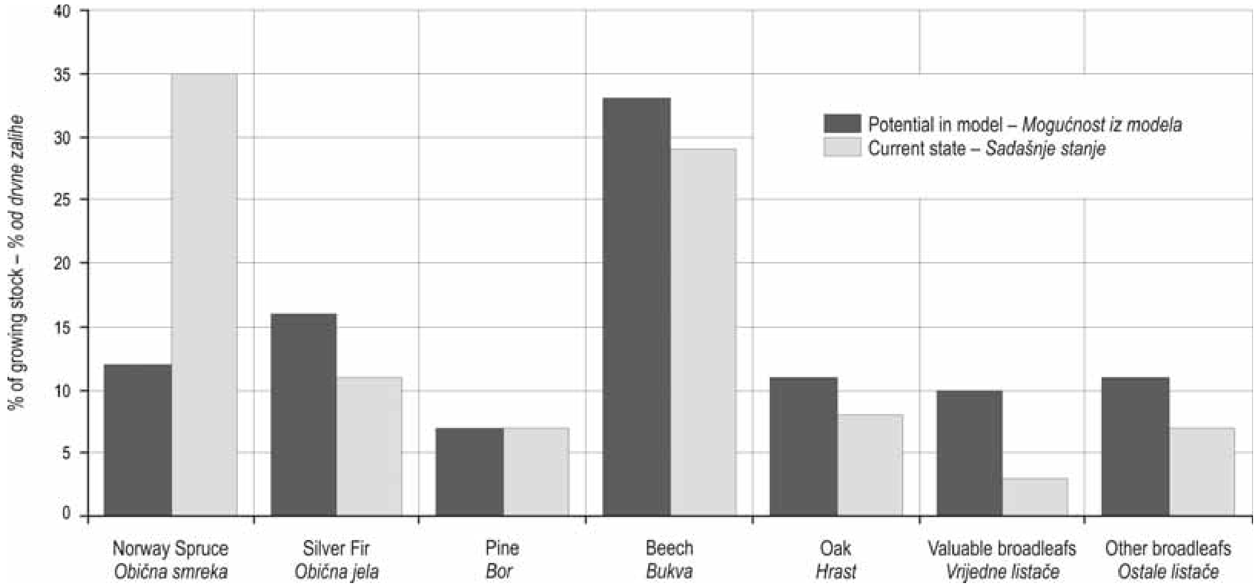

Fig. 1 Differences among potential and current shares in growing stock of joined groups of tree species

Slika 1. *Razlike između mogućih i sadašnjih udjela u drvnoj zalihi skupina vrsta drveća*

share of silver fir is higher, and only in some varieties of the association the beech prevails. In Eastern Alps the similar association of silver fir–beech (besides higher share of Norway spruce) gets also some Scots pine. The Norway spruce in Slovenia on the other hand does not cover vast Subalpine areas as it does in neighbouring countries, but we can find it on extreme sites, on silicate or dolomite bedrock, on rocky ground all the way to the lowland. On some sites the Scots pine appears making mixed forests together with spruce trees. The forests of high value broadleaf lack *Tilia platyphyllos* Scop. On the other hand *Acer platanoides* L. gets a more important role and can in some cases even prevail in the tree structure of a certain site. A special structure is also characteristic of beech forest on extreme silicates where Norway spruce has a good natural vitality. Such forest can in other cases have similarities with lowland silver fir forests on silicate bedrock. In the Western Slovenia in the coast direction the share of Illyric tree species becomes encreasingly larger, but these are already the specialities of the Submediterranean area.

Input data for each forest stand have been taken from the Slovenian forest data base, which is maintained by the Slovenian Public Forest Service and comprises 78,667 entries for the area of 1,116,206 ha of forests. Many of the forest stands have been drastically changed by the management in the history because of different reasons. Some privately owned areas have been overexploited or changed according to the needs of forest owners; on the other hand some areas have been changed into merely spruce stands or influenced in many other ways. Despite such changes, the majority of forests have remained in more or less co-natural state, which is especially true for the state forests.

4. Results – *Rezultati*

The examination of the differences between the current and potential vegetation cover is of great

Table 1 Determination of scenarios for approaching natural stand structures varying thinning intensities and rotation period

Tablica 1. *Određivanje nacrta gospodarenja za prevođenje sastojina u prirodnu strukturu mijenjanjem intenziteta proreda i duljina ophodnji*

Thinning Intensity – *Intenzitet prorede*	Rotation period – *Duljina ophodnje*		
	120 years – *120 godina*	140 years – *140 godina*	160 years – *160 godina*
Weak – *Slab*	Scenario 1 – *Nacrt 1*	Scenario 2 – *Nacrt 2*	Scenario 3 – *Nacrt 3*
Mean – *Umjeren*	Scenario 4 – *Nacrt 4*	Scenario 5 – *Nacrt 5*	Scenario 6 – *Nacrt 6*
Strong – *Jak*	Scenario 7 – *Nacrt 7*	Scenario 8 – *Nacrt 8*	Scenario 9 – *Nacrt 9*

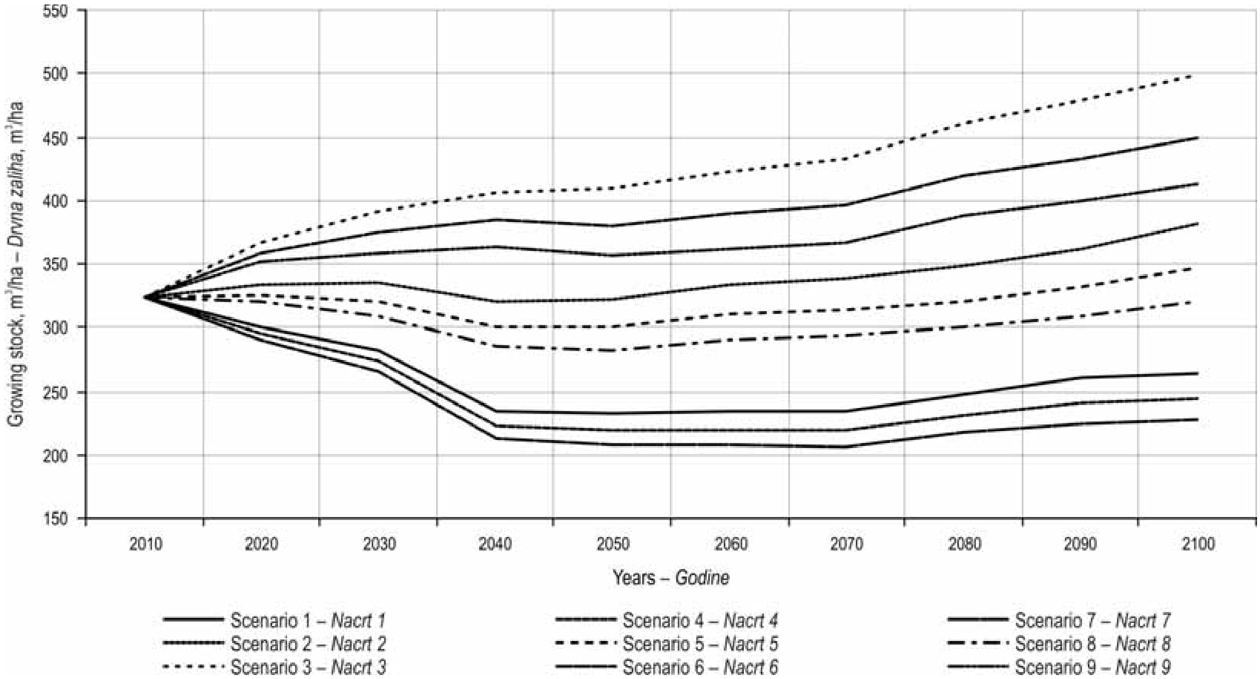

Fig. 2 Model predicting average growing stock development in forest management unit according to different scenarios

Slika 2. *Model predviđanja prosječnoga razvoja drvne zalihe gospodarske jedinice pri različitim nacrtima gospodarenja*

interest since it is important for the model behaviour. The greater the difference, the longer the period of adaptation to the closer-to-nature state of forests. The intensity of thinning also depends upon this difference, as well as many other outputs of the model. The differences among the potential and current shares in growing stock of the joined groups of tree species are shown in Figure 1 (source of the current vegetation shares: The Forest Development Programme of Slovenia, 1995).

Briefly, as shown in Fig. 1, the greatest difference is caused by the disproportion of the Norway spruce share in growing stock in the past. If the final goal is the co-natural forest structure, more intensive cuttings are expected in spruce stands in the next decades. The priorities should be given to those tree species, which are at present almost minorities, but with great natural potential (Krč 1999a, Krč 1999b).

The final goal of forest development dynamics in the model is determined in Appendix 1. The input status is determined by the forest inventory base, and there is only the question of procedures, which are built into the model. Those procedures are out of the scope of this paper, but we wish to emphasise the fact that various paths to the final goal have been researched within the time range of 90 years. Alternative forest management scenarios were defined by the rotation period and thinning intensity (Table 1), which was controlled by the target state of stand structure. The target stand structure was defined by the tree species volume composition suitable for the specific site plant association and with respect to the current forest development phase.

The model has been tested so far in a case study of one forest management unit in the Alpine region, and we tested the impact of rotation period and thinning intensity on the final result. Simulations showed that the intensity of cuttings and given priorities influence the final success (Krč 1999). The influence of the length of rotation period has also an important impact on higher or lower stumpage values. One of the elementary figures is shown in Fig. 2. The best scenarios for obtaining the highest growing stock in the period up to 2080 are 3, 6 and 9, which means (Table 1) a very long rotation period of 160 years. Within this choice weak thinning intensity will yield the best results – the highest growing stock with the tree composition, which will not differ very much from the present one. »Volume« and »Value« are many times on the opposite sides of the formula. It is hard to predict which option is the best from the point of view of stumpage price. Further analysis must still be done with a more detailed consideration of the technology costs and trends of market prices.

Dependence of stumpage value on cost and stand value is broadly known (Winkler 1996) and will not be discussed in this paper. Our interest was focused

Table 2 Proportions between cutting volumes according to different rotation periods and thinning intensities
Tablica 2. *Odnosi između obujma posječenoga drva za različite duljine ophodnji i intenzitete proreda*

Thinning Intensity – *Intenzitet prorede*	Weak – *Slab*			Mean – *Umjeren*			Strong – *Jak*		
Rotation period – *Duljina ophodnje*	120	140	160	120	140	160	120	140	160
Thinning – *Proreda*	100	171	250	100	170	244	100	170	246
Final cutting – *Dovršna sječa*	100	84	65	100	82	62	100	83	63
Total – *Ukupno*	100	105	110	100	106	113	100	106	112

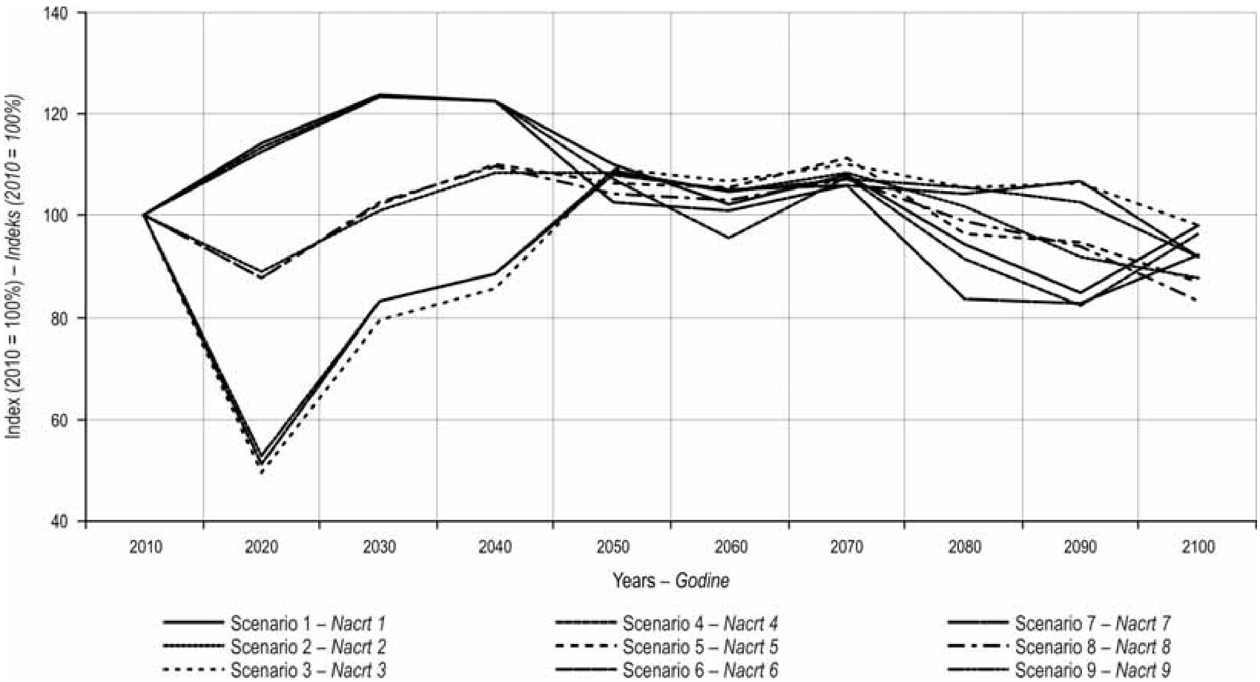

Fig. 3 Model predicting stumpage prices according to different scenarios
Slika 3. *Model predviđanja cijena drva na panju pri različitim nacrtima gospodarenja*

on stand development as a basis for stumpage price and other calculations. Simple, but not precisely accurate assumptions are: higher increment = more wood = higher stumpage price and to be specific: more softwood = higher stumpage price.

It can be seen in Table 2 that there are not very big differences between thinning intensities within the same rotation period. A longer production period nevertheless means greater cutting volume. The structure of the cutting volume gives very different results in the first several decades (Fig. 3). At the end of modelled time span the differences between scenarios will decrease and will be less than 20% of the basic stumpage price. This final period will also be the time where co-natural structure of the forest will be normal and the differences in production periods in the majority of stands will not be crucial. The similarity between scenarios in this light is therefore normal/expected.

The whole forecasting period can be divided into three time intervals, the results of which are influenced by current (initial) strand structures (year 2010), where older development phases in Forest Management Unit prevail:

1. From 2010 to 2050 where the best result is obtained by short rotation scenarios and the worst by long rotation period scenarios;
2. From 2050 to 2070 where the differences between different scenarios are small, but short production periods are already in the worst position;
3. From 2070 to 2100 where the differences between scenarios go up and down following the tendency that the lowest stumpage prices are achieved by short rotation periods.

5. Discussion – *Rasprava*

Models of forest development dynamics can be/ constitute an excellent base for many other calculations, but their accuracy depends upon the procedures and input data. In our case the crucial base of the model is the natural state of tree species according to the main vegetation types. This table was developed on the basis of broad knowledge about the vegetation composition and succession of natural plant associations in Slovenia. Discrepancies between the goal and the actual state of a specific stand can be very large in extremes, but the problem of co-natural forest management for the majority of forests can be solved with satisfying accuracy. Despite this, further investigations of plant association succession on sensitive or devastated sites are still needed. The model showed that the worst case for the owner (lowest stumpage price) in the next decades is the case with long production periods, the best are scenarios with short rotation periods, where unnatural spruce stand are converted to co-natural structure in three decades. In the far future the situation will change when longer production periods show slightly higher stumpage prices. Further model development and promotion of their use are also of the outmost importance. Additionally, there is urgent need for future research of the forest stumpage correlated with technological development and investment in the forest.

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Appendix 1 Potential natural composition of the tree species according to the vegetation association, %
Dodatak 1. *Mogući prirodni sastav vrsta drveća po biljnim zajednicama, %*

Plant association *Biljna zajednica*	Norway Spruce *Obična smreka*	Silver Fir *Obična jela*	European Larch *Europski ariš*	Scots Pine *Obični bor*	Austrian Black Pine *Austrijski crni bor*	Common Beech *Obična bukva*	Pedunculate Oak *Hrast lužnjak*	Sessile Oak *Hrast kitnjak*	Maple *Javor*	Elm or Ash *Brijest ili jasen*	Other hardwood *Ostale tvrde listače*	Other softwood *Ostale meke listače*
Group – *Skupina*	1	2	3	4	5	6	7	8	9	10	11	12
Lowland and floodplain forest – *Nizinske i poplavne šume*												
Querco robori-Carpinetum							80			5	10	5
Querco robori-Carpinetum abietetosum		30					60		5		5	
Querco robori-Ulmetum							50			50		
Carici elatae-Alnetum glutinosae										95		5
Carici elongate-Alnetum glutinosae										95		5
Carici brizoidi-Alnetum glutinosae							15			80	5	
Alnetum glutinoso-incanae										70		30
Alnetum incanae									20			80
Salici-Populetum										5		95
Forests of the hills – *Šume brežuljaka*												
Hacquetio-Carpinetum						20		70			10	
Hacquetio-Carpinetum var. *Luzula luzuloides*						15		65			20	
Ornithogalo-Carpinetum							60	30			10	
Submountain beech forests – *Submontanske bukove šume*												
Hedero-Fagetum var. *Ruscus*						90	1	3	3		3	
Hedero-Fagetum var. *Hieracium rotundifolium*						90		5	3		2	
Hedero-Fagetum festucetosum drymeae						90			8		2	
Hacquetio-Fagetum s. latiss.						90		5	2		3	
Mountain beech forests – *Brdske bukove šume*												
Dentario-Fagetum var. *Dentaria polyphyllos*						94			5			1
Dentario-Fagetum var. *Helleborus macrantus*						90			8		2	
Arunco-Fagetum						90		1	8		1	
Lamio orvalae-Fagetum		20				75			5			
Silver fir-Beech forests – *Jelovo-bukove šume*												
Abieti-Fagetum v. geogr. *omphalodes* s. latiss.	8	55				35			2			
Abieti-Fagetum v. *festucetosum*	1	35				63			1			
Abieti-Fagetum v. *mercurialetosum*	2	47				50			1			
Abieti-Fagetum v. *asperuletosum (omphalodetosum)*	2	45				52			1			
Abieti-Fagetum v. *lycopodietosum*	10	55				35						
Abieti-Fagetum "praealpinidinaricum"	10	50				35			5			
Abieti-Fagetum v. geogr. *Anemone trifolia (= praealpinum)*	18	35				45			2			
Prealpine beech forests – *Pretplaninske bukove šume*												
Anemono-Fagetum typicum	5		1			90			4			
Anemono-Fagetum abietetosum	3	25				70			2			
Anemono-Fagetum vaccinietosum	15		5			80						
Anemono-Fagetum homogynetosum	15	5	3			75			2			
Anemono-Fagetum laricetosum	20		20			60						
High mountain beech forest – *Visokoplaninske bukove šume*												
Savensi-Fagetum						90			10			
Adenostylo glabrae-Fagetum		15				75			10			
Isopyro-Fagetum						85			15			
Aceri-Fagetum		20				60			20			
Polysticho-Fagetum (= subalpinum)	10					90						

Appendix 1 Potential natural composition of the tree species according to the vegetation association, %

Dodatak 1. *Mogući prirodni sastav vrsta drveća po biljnim zajednicama, %*

Plant association *Biljna zajednica*	Norway Spruce *Obična smreka*	Silver Fir *Obična jela*	European Larch *Europski ariš*	Scots Pine *Obični bor*	Austrian Black Pine *Austrijski crni bor*	Common Beech *Obična bukva*	Pedunculate Oak *Hrast lužnjak*	Sessile Oak *Hrast kitnjak*	Maple *Javor*	Elm or Ash *Brijest ili jasen*	Other hardwood *Ostale tvrde listače*	Other softwood *Ostale meke listače*
Group – *Skupina*	1	2	3	4	5	6	7	8	9	10	11	12
Subtermofilic beech forests – *Suptermofilne bukove šume*												
Seslerio-Fagetum						85		5			10	
Ostryo-Fagetum						65			5		30	
Carici albae-Fagetum	3					85			2		10	
Calamagrostio variae-Fagetum	5					85			3		7	
Subacidifilic and acidifilic beech forests – *Supacidofilne i acidofilne bukove šume*												
Hieracio rotundati-Fagetum typicum						95		5				
Hieracio rotundati-Fagetum deschampsietosum				1		90		7			2	
Luzulo-Fagetum var. *Polygonatum verticillatum*	2	2				94			2			
Acidofilic beech forests – *Acidofilne bukove šume*												
Blechno-Fagetum typicum	5			2		90		3				
Blechno-Fagetum luzuletosum						90		10				
Blechno-Fagetum abietetosum	3	20				75		2				
Subacidofilic silver fir forests – *Supacidofilne jelove šume*												
Sorbo-Abietetum mercurialetosum	10	75				10			5			
Homogyno sylvestris-Abietetum	15	75				8			2			
Lycopodio-Abietetum	25	75										
Neckero-Abietetum	10	85				3			2			
Asplenio-Abietetum	10	90										
Festuco-Abietetum	5	90				5						
Dryopterido-Abietetum s. latiss.	5	85				3		2	5			
Dryopterido-Abietetum melampyretosum sylvaticae	5	90				5						
Dryopterido-Abietetum var. *Carex sylvatica*		90				5		2	3			
Acidofilic silver fir forests – *Acidofilne jelove šume*												
Luzulo sylvaticae-Abietetum	5	90				4		1				
Bazzanio-Abietetum	20	80										
Norway spruce forests – *Šume obične smreke*												
Asplenio-Piceetum	80	5	15									
Carex albae-Piceetum var. *Ostrya carpinifolia*	90			5		3			2			
Calamagrostio variae-Piceetum	90			9							1	
Adenostylo glabrae-Piceetum	85		10			5						
Piceetum "montanum" (= Hacquetio-Piceetum)	100											
Ribeso alpini-Piceetum	50	50										
Piceetum »subalpinum dinaricum«	80	15				2			2		1	
Sorbo-Piceetum	100											
Bazzanio-Piceetum	80	20										
Sphagno-Piceetum	100											
Bazofilic pine forests – *Bazofilne borove šume*												
Genisto-Pinetum	3			95							2	
Pinetum subillyricum	10			85		5						
Orno-Pinetum nigrae					100							
Erico-Pinetum	10		5	85								
Bazofilic oak forests – *Bazofilne hrastove šume*												
Lathyro-Quercetum petraeae							70				30	
Orno-Quecetum pubescentis					2			50			48	
Carici umbrosae-Quercetum petraeae								70			30	
Seslerio autumnalis-Quercetum petraeae						20		70			10	

Appendix 1 Potential natural composition of the tree species according to the vegetation association, %

Dodatak 1. *Mogući prirodni sastav vrsta drveća po biljnim zajednicama, %*

Plant association *Biljna zajednica*	Norway Spruce *Obična smreka*	Silver Fir *Obična jela*	European Larch *Europski ariš*	Scots Pine *Obični bor*	Austrian Black Pine *Austrijski crni bor*	Common Beech *Obična bukva*	Pedunculate Oak *Hrast lužnjak*	Sessile Oak *Hrast kitnjak*	Maple *Javor*	Elm or Ash *Brijest ili jasen*	Other hardwood *Ostale tvrde listače*	Other softwood *Ostale meke listače*
Group – *Skupina*	1	2	3	4	5	6	7	8	9	10	11	12
Acidofilic oak forests – *Acidofilne hrastove šume*												
Luzulo-Quercetum petraeae						10		85			5	
Melampyro-Quercetum petraeae						20		75			5	
Acidofilic Scotch pine forests – *Acidofilne borove šume*												
Vaccinio vitis-ideae-Pinetum	10			85		3		2				
Myrtillo-Pinetum	10			90								
Forests of broadleaf of high value – *Visokovrijedne šume listača*												
Ostryo-Aceretum platanoidis						10			70		20	
Dentario enneaphylli-Aceretum pseudoplatani						20			80			
Lamio-Fraxinetum excelsioris						20			80			
Carici remotae-Fraxinetum		5					5		80	5	5	
Carici remotae-Fraxinetum abietetosum		50							45		5	
Termophillic Illiryc bush like forests – *Degradacijski stadiji termofilnih ilirskih šuma*												
Querco-Ostryetum								5			95	
Ostryo-Fraxinetum ornii				5							95	
Cytisanto-Ostryetum											100	
Tilio plathyphylli-Ostryetum						5			35		60	
Seslerio-Ostryetum						2		3			90	
Slovenia – *Slovenija*	12	16	1	5	1	33	4	7	6	4	8	3

Tree composition of the groups in Appendix 1 – *Sastav vrsta drveća po skupinama u dodatku 1*

Group – *Skupina*	Species – *Vrste drveća*
1	*Picea abies* (L.) Karst.
2	*Abies alba* Mill.
3	*Larix decidua* Mill.
4	*Pinus sylvestris* L.
5	*Pinus nigra* Arnold
6	*Fagus sylvatica* L.
7	*Quercus robur* L.
8	*Quercus petraea* (Matt.) Liebl.
9	*Acer pseudoplatanus* L., *Acer platanoides* L., *Fraxinus excelsior* L., *Tilia platyphyllos* Scop., *Fraxinus oxycarpa* Willd., *Alnus glutinosa* (L.) Gaertn., *Tilia cordata* Mill.
10	*Ulmus glabra* Huds., *Ulmus laevis* Pallas
11	*Carpinus betulus* L., *Acer campestre* L., *Prunus avium* L, *Sorbus torminalis* (L.) Cr., *Ostrya carpinifolia* Scop., *Sorbus aria* (L.) Cr., *Quercus cerris* L., *Sorbus aucuparia* L.
12	*Popupus tremula* L., *Populus alba* L., *Salix alba* L., *Betula pendula* Roth., *Alnus incana* (L.) Moench

Sažetak

Prirodni sastav vrsta drveća kao osnova razvoja modela cijena drva na panju

Razvoj i korištenje modela imaju važnu ulogu u istraživanju i gospodarenju šumama u Sloveniji. Kako se šumama potrajno gospodari na način blizak prirodnomu, nužno je osloniti se na postojeća znanja o sastavu biljnih zajednica. Rad opisuje potrebu za modeliranjem cijena drva na panju, te osnovnu zamisao razvoja modela koji se može ponašati dinamično kako se struktura šuma približava konačnomu cilju – strukturi vrsta drveća koja je bliska prirodnoj. Glavne biljne zajednice u Sloveniji i njihova svojstvena struktura drveća predstavljaju tzv. ciljni model. Ulazni podaci preuzeti su iz baze podataka nacionalne inventure šuma i uspoređeni s ciljnim modelom. Razlika između modelom oblikovane i stvarne strukture drveća, zajedno s rastom i drugim varijablama, daje intenzitet i strukturu propisanoga godišnjega sječnoga obujma drva (etat) te samim time i vrijednost drvnih sortimenata. Pomoću modela razvijeno je i nekoliko mogućih nacrta gospodarenja za sljedeća desetljeća, a modeli su se pokazali kao dobra osnova za donošenje odluka. Pojedini nacrt gospodarenja određen je intenzitetom prorede (slaba, umjerena, jaka) i duljinom ophodnje (120, 140, 160 godina).

Modeli kretanja razvoja šuma mogu biti, odnosno čine izvrsnu osnovu za mnoge druge proračune, čija točnost ovisi o procedurama i ulaznim podacima. U prikazanom je slučaju važna osnova za model prirodan sastav vrsta drveća prema glavnim vegetacijskim tipovima. Tablica u dodatku napravljena je na osnovi znanja o sastavu vegetacije i sukcesiji prirodnih biljnih zajednica u Sloveniji. Odstupanja između ciljnoga i stvarnoga stanja pojedinih sastojina mogu u ekstremnim slučajevima biti vrlo velike, ali problem gospodarenja sastojinama koje su bliske prirodnima za većinu se može riješiti sa zadovoljavajućom točnošću. Usprkos navedenomu potrebna su daljnja istraživanja sukcesije biljnih zajednica na osjetljivim ili oštećenim staništima.

Modeli pokazuju da je u sljedećim desetljećima najnepovoljnija situacija za šumovlasnika (najniža cijena drva na panju) ona s najduljim vremenom ophodnje, a najpovoljniji je nacrt gospodarenja kratke ophodnje, gdje se smrekove kulture prevode u sastojine koje su po sastavu bliske prirodnima u razdoblju od tri desetljeća. Pretpostavka je da će se u budućnosti situacija promijeniti, pa će dulje ophodnje sastojina prouzročiti porast cijena drva na panju. Daljnji razvoj modela i promicanje njihova korištenja imaju najveće značenje za gospodarenje šumama. Također je potrebno hitno istražiti povezanost vrijednosti drva stojećega stabla s tehnološkim razvojem i investicijama u šumarstvu.

Ključne riječi: *biljne zajednice, cijena drva na panju, gospodarenje šumama, model*

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