IZVORNI I ZNANSTVENI ČLANCI – ORIGINAL SCIENTIFIC PAPERS
UDK 630* 182 (001)

Šumarski list br. 11–12, CXXXIV (2010), 581-591

SPECIES COMPOSITION AND SUCCESSIONAL PATHWAYS ON ABANDONED AGRICULTURAL LAND IN HALOZE

VRSTE DRVEĆA I GRMLJA TE STRATEGIJA ZARASTANJA NAPUŠTENOG POLJOPRIVREDNOG ZEMLJIŠTA NA PODRUČJU HALOZA U SLOVENIJI

Mateja COJZER*, Robert BRUS**

SUMMARY: In Slovenia, as well as in others parts of Europe, the share of abandoned agricultural land overgrown by forest has been increasing every year. This article deals with this process of succession in Haloze, in the north-eastern part of Slovenia. The main aim of this research was to find out how much of the abandoned agricultural land on the studied area has succeeded to forest in the last 20 years, to examine differences in species composition and the density of individuals of tree and shrub species between abandoned areas and younger developmental phases of forest, as well as to point out the strategies of succession on abandoned areas and compare them with the vegetation process of younger developmental phases in forest. Forest area increased by 7 % in the period from 1985 to 2005 in the study region. The results show that the successional process on abandoned land starts with shrub species, while in younger phases of forest, tree species prevail entirely.

Key words: abandoned agricultural land, successional pathways on abandoned land, old-field succession, vegetation process in forest, species composition, density of individuals, younger developmental phases of forest, the Haloze region.

1. INTRODUCTION – Uvod

Dense forest cover is one of the basic features in Slovenia, where forests cover more than half (58.4 %) of the total territory (ZGS, 2007). This is in large part because Slovenia is a mountainous country. More than one third of the land area is above the altitude of 600 m, and two thirds of this area is forested. Approximately half of the land has a slope incline greater than 20 % and a good fifth more than 35 % (Perko, 2004). Forest has been mainly preserved at higher and steeper locations, which are less suitable for agriculture.

The amount of forest area in Slovenia is still increasing. The main reasons for this are: the abandonment of farmland and agricultural land (grasslands, pastures, vineyards, meadows and orchards) (Perpar, 2002); a decrease in livestock pressure; inconvenient natural conditions; and socio-economic and political circumstances (Golob et al., 1994). This process has been going on since the beginning of the last century, and at an accelerated rate after World War II (Hudoklin, 2004). During the second half of the 20th century, the mountainous and hilly areas in Slovenia were abandoned and suffered high population emigration (Mlinšek, 1968; Cunder, 1998; Kobler, 2001; Hočevar et al., 2004; Kozorog, 2004; Kobler et al., 2005). The changes in land use during the last 60 years have led to extensive re-vegetation with an increase in shrubs and forests. According to ZGS (2007), the forest area has increased by 60.5 % in the last 130 years and by 34.6 % since 1947. Similar to other parts of Slovenia, the share of forest area and abandoned agricultural land have increased in the Haloze region, for the same aforementioned reasons.

Succession on abandoned agricultural land has become a serious problem not only in Slovenia, but also elsewhere in Europe (Borec et al., 2004). In studies

* Mateja Cojzer, univ. dipl. inž. gozd., ZGS, OE Maribor, Tyrševa 15, 2000 Maribor, Slovenia, mateja.cojzer@zgs.gov.si
** Prof. dr. Robert Brus, univ. dipl. inž. gozd., Biotechnical Faculty, Department of Forestry and Renewable Forest Resources, Večna pot 83, 1000 Ljubljana, Slovenia, robert.brus@bf.uni-lj.si

conducted throughout Europe, most studies have examined natural and socio-economical factors associated with old-field succession (Walther, 1986; Baldock et al., 1996; MacDonald et al.; 2000; Mather, 2001; Kozak, 2003; Kobler et al., 2005; DLG, 2005; Lasanta et al., 2006; Gellrich, 2007; Pueyo and Begueria, 2007; Rickebusch 2007;). There is, however, a lack of research on tree and shrub composition on abandoned land and a lack of research on planned management of successive changes of stands, which occurred in these areas. Even rarer are studies that investigate the hilly Sub-Pannonian district, such as Haloze. Consequently, our research in these abandoned areas focused on the species composition, which is extremely rich in the north-eastern part of Slovenia.

Specifically, our objectives were to:

- Determine how much of the Haloze area has become overgrown in the period from 1985 to 2005, and what the estimated area of forests will be by the year 2015;
- Study the differences in composition and density of shrub and tree species between abandoned land and forest;
- Study the strategies of succession on the abandoned land and compare them to the vegetation dynamics in forest.

2 MATERIAL AND METHODS – Materijal i metode

2.1 Research area – *Područje istraživanja*

This research was carried out in Haloze (at 46°19´N, 15°52´E), in the north-eastern part of Slovenia.

The hilly relief of Haloze is very steep with numerous valleys and ditches (Belec, 1961). The absolute altitudes on the study area range from 220 to 458 m a.s.l. The climate is Sub-Pannonian and is characterised by hot summers, dry and sunny early autumns, and cold winters. The annual mean air temperature is 9.7°C (Klimatografija Slovenije, 1995), and the average temperature during the vegetation period is 15.3°C. The average annual precipitation varies from 928 up to 1.075 mm/m^2 (Bračič, 1982). Geology in the region consists of Miocene sediments, mainly covered by dystric soil on marl and marl sandstone (Belec, 1961). The Haloze region is on the Sub-Pannonian margin of the Predinaric phytoclimatic territory (Košir, 1994). The study area is dominated by beech forest sites. Neutrophilic beech forests (*Hedero-Fagetum* Košir /62, 79/ 94) grow in rich and moist habitats, while acidophilic beech forests (*Castaneo-Fagetum sylvaticae* /Mar. & Zup. 79/ Mar. & Zup. 95) grow on well-drained and dry sites with an irregular water supply. The syntaxonomic nomenclature in this study follows Robič and Accetto (1999).

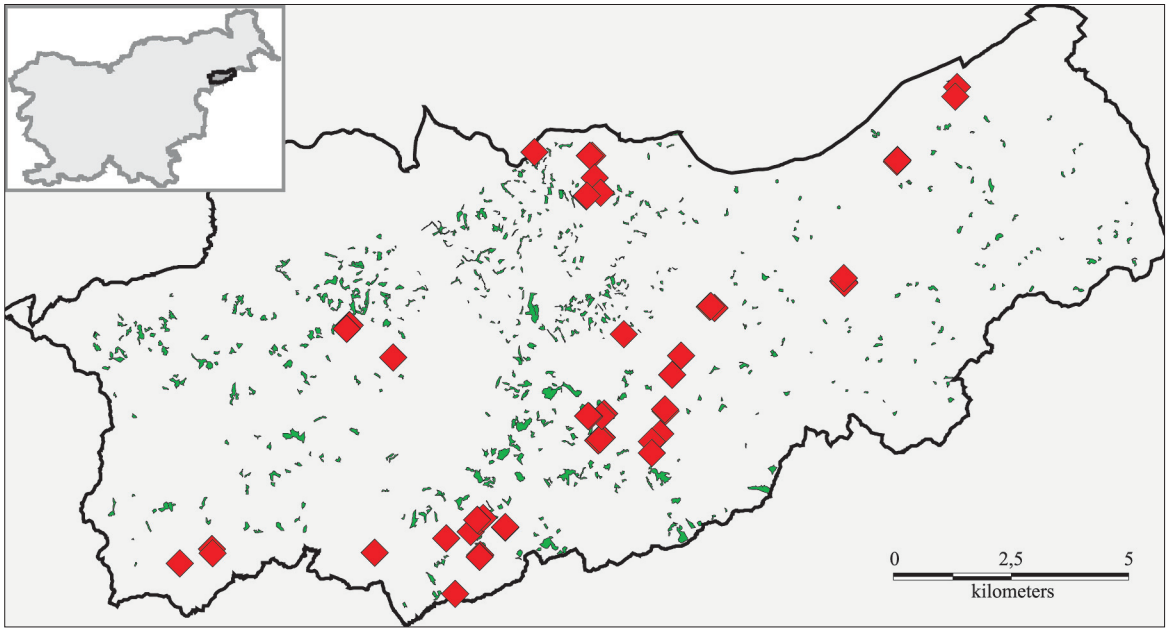

Figure 1 Locations of the research plots in the study area in north-eastern Slovenia (Slovenia Forest Service)
Slika 1. Lokacije istraživačkih ploha na području istraživanja, koje leži na sjeveroistočnom djelu Slovenije

2.2 Data collection – *Prikupljanje podataka*

Abandoned land areas were recorded in the latest forest management plans for the Vzhodne Haloze and Rodni vrh units (ZGS 2005a, 2005b). This database was used as a basis to determine the plot site locations. Plot locations were chosen on the basis of digital orthophotos (scale 1:5.000). Important criteria for choo-

sing plots were the size, the shape and the developmental stage of the abandoned land. All plots were square shaped and north-east oriented.

Vegetation records were carried out on 52 plots in total. 37 plots (20x20 m) were set on abandoned agricultural land, of which 5 were in young growth developmental stages, 15 in a thicket phase, and 17 in a pole stand phase. 15 plots (20x10 m), 5 for each developmental phase, were analysed in forest areas. The survey was carried out from the beginning of August until the end of October 2006, and in September 2007. Each plot was set according to its developmental phase (one plot – one developmental phase), and its floristic composition was recorded by counting the individuals of tree and shrub species. The source of the plant nomenclature was the Mala flora Slovenije (Martinčič et al., 2007).

To analyse the vegetation composition for every single developmental phase, an appropriate treatment was assigned to each study plot. Six equivalent treatments were: A – abandoned land in young growth phase, B – abandoned land in thicket phase, C – abandoned land in pole stand phase, D – forest in young growth phase, E – forest in thicket phase, F – forest in pole stand phase. All vegetation samples which were carried out on abandoned land, together created Z treatment, and all vegetation samples which were carried out on forest plots, formed G treatment.

2. 3 Statistical analyses – *Statističke analize*

MapInfo v. 8.5 software was used for spatial data processing, and Excel for data analysis. Statgraphics Plus for Windows software was used for statistical data processing. Data were analysed by analysis of variance (One-way ANOVA), where parametric (t-test) and non-parametric tests (LSD test, Duncan variance homogeneity test) were used. Since the number of subjects per ha is not a normally distributed variable, a preliminary »square root« transformation was performed for the ANOVA. Species diversity was calculated by the Shannon's diversity index (H'; $H' = -\Sigma(p_i \ln p_i)$) (Shannon, 1948). CANOCO 4.5 for Windows (ter Braak and Šmilauer, 2002) was used for calculation. The number of species per plot (species composition), their stability, and species density (the number of species individuals per ha) were calculated for each plot separately. Species stability was calculated according to the share of individual species occurrence in the previous samples. We analysed the plot similarity vegetation composition by using the detrended correspondence analysis (DCA), considering the number of individuals per ha. DCA analysis was carried out with the help of CANOCO 4.5 for Windows (ter Braak and Šmilauer, 2002).

3 RESULTS – Rezultati

3. 1 The share of forest area and abandoned land – *Udio šumskih površina i zemljišta u zarastanju*

In twenty years (1985-2005) the forest area of Haloze increased by 6.9 % (Tab. 1). The share of forest cover in the Haloze region is thereby 42.2 %, but twenty years ago it used to be 39.4 %. And, if (by the next forest management plan renewal) all presently recorded areas of abandoned land are classified as forest, in 2015 (comparably to the year 1985) the forest area will have increased by 13.0 %, and the total forest area of Haloze will total 44.5 %.

Table 1 Changes in the forest area in Haloze in the period from 1985 to 2005 (ZGS, 2005)

Tablica 1. Promjena šumskih površina u Halozama od 1985 do 2005 godine

Year *Godina*	Forest area *Površina šuma* (ha)	Index *Indeks* (%)
1985	6916.70	100.0
2005	7396.70	106.9
2015	7803.49	112.8

3. 2 Species composition and density of individuals (on abandoned land and forest) – *Vrste drveća i grmlja te gustoća jedinki (na napuštenom zemljištu te u šumi)*

Abandoned land was more species diverse than forest; 47 species were identified on abandoned land (33 tree and 14 shrub species), and 36 species in forest (25 tree and 11 shrub species) (Tab. 4).

With regard to the treatment, the ordination shows (Fig. 2), that by the first axis, which explains most of the variability, we can distinguish between two groups of samples: abandoned land (Z – treatment) and forest (G - treatment). The total inertion of DCA is 6.281; the eigenvalues of the first four axes were 0.728, 0.470, 0.322, 0.201, which cumulatively explained 11.6 %, 19.1 %, 24.2 %, 27.4 % of variability in species data. Gradient length of the first axis is 4.663, which justifies the use of uni-modal ordination methods (ter Braak and Šmilauer, 2002). The second axis shows a relatively high variability in vegetation composition per plot on abandoned land and a little lower variability in forest.

Table 2 shows the average number of species per plot. There was no difference in average number of all species per plot, and in the average number of tree spe-

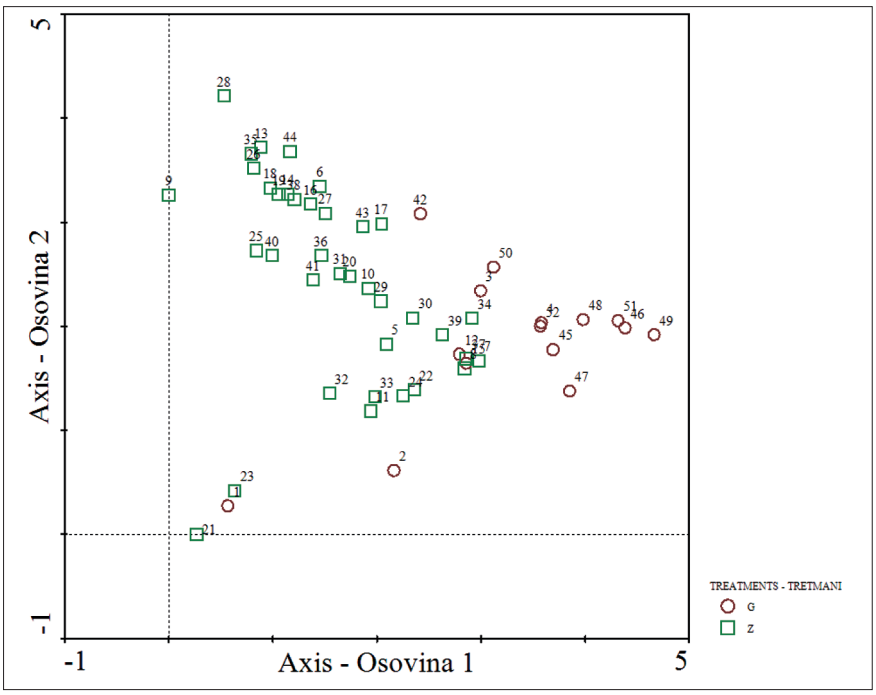

Figure 2 DCA ordination plot of 52 vegetation samples. Samples are marked with the symbols denoting the treatment (Z – abandoned land, G – forest). First and second axes explain 11.6 % and 7.5 % of variability in species data, respectively.

Slika 2. DCA ordinacija popisa označenih po tretmanima (Z – zemljište u zarastanju, G – šuma). Prva os pojašnjava 11,5 % a druga 7,5 % varijabilnosti podataka o distribuciji vrsta po popisima.

cies per plot between forest and abandoned land at $p<0.05$. But there was a significant difference in the average number of shrub species per plot.

In forest there were mainly (91.5 %) tree species individuals, while shrub species represent only 8.5 %. On abandoned land the proportion was more balanced, where tree species represent 53.0 %, and shrub species 47.0 % of the share. In the forest area, *Fagus sylvatica* was the most abundant tree species, followed by *Carpinus betulus* and *Quercus petraea*. For shrubs, *Sambucus nigra* was the dominant species, followed by *Corylus avellana* and *Cornus sanguinea*. On abandoned land, *Carpinus betulus* was the dominant tree species, followed by *Alnus glutinosa* and *Acer pseudoplatanus*. Among the shrub species, *Cornus sanguinea* was the most abundant, followed by *Corylus avellana* and *Prunus spinosa*.

Table 2 The average number of species per plot separately according to treatments (Z - abandoned land, G - forest)

Tablica 2. Prosječan broj vrsta po jedinici popisa (plohi) s obzirom na tretmane (Z - napušteno zemljište, G - šuma)

Treatments *Tretmani*	Count *Broj ploha*	All species *Sve vrste*			Tree species *Vrste drveća*			Shrub species *Vrste grmlja*		
		Average number per plot *Prosječan broj na plohi*	*F*	*p*	Average number per plot *Prosječan broj na plohi*	*F*	*p*	Average number per plot *Prosječan broj na plohi*	*F*	*p*
G	15	12.3			9.7			2.7		
Z	37	13.7			9.2			4.4		
G x Z			1.01	0.312		0.16	0.691		8.74	0.005

Table 3 The density of individuals per ha separately according to treatments (Z - abandoned land, G - forest)

Tablica 3. Gustoća jedinki na hektar, prikazano po tretmanima (Z - napušteno zemljište, G - šuma)

Treatments *Tretmani*	Count *Broj ploha*	All species *Sve vrste*			Tree species *Vrste drveća*			Shrub species *Vrste grmlja*		
		Average number of individuals *Prosječan broj jedinki* (ha^{-1})	*F*	*p*	Average number of individuals *Prosječan broj jedinki* (ha^{-1})	*F*	*p*	Average number of individuals *Prosječan broj jedinki* (ha^{-1})	*F*	*p*
G	15	23906.3			21884.0			2022.3		
Z	37	19447.2			10301.2			9146.0		
G x Z			1.17	0.203		12.02	0.001		17.32	<0.001
Transformation *Transformacija*		Sqrt (number of individuals all species ha^{-1}) *Korijen(broj jedinki svih vrsta na ha)*			Sqrt (number of individuals tree species ha^{-1}) *Korijen (broj jedinki vrste drveća na ha)*			Sqrt (number of individuals shrub species ha^{-1}) *Korijen (broj jedinki vrste grmlja na ha)*		

It is evident (Tab. 3) that the species density of species individuals was a little higher in forest than on abandoned land. There was no difference in the density of all species individuals at $p<0.05$ between the forest and abandoned land treatments. But there was a difference in the density of tree species individuals and in the density of shrub species individuals. In forest the density of tree species individuals was twice as high as the density of tree species individuals on abandoned land. And the density of shrub species individuals was considerably higher on abandoned land than in forest.

Table 4 The average number of individuals per plant species, separately for forest and abandoned land and according to treatments (developmental phases). Data are shown as a number of individuals ha^{-1}.

Tablica 4. Prosječan broj jedinki pojedinih vrsta drveća i grmlja, posebno za šumu i napuštena zemljišta te odvojeno/posebno po tretmanima (stadiji razvoja šuma). Podaci su izraženi u brojevima jedinki po hektaru.

Species *Vrste*	Tree/ shrub *Drveće/ grmlje*	Forest *Šuma*		Abandoned land *Napuštena zemljišta*		Treatments *Tretmani*					
		Average number of individuals *Prosječan broj jedinki* (ha^{-1})	Presence number of plot *Frekvencija pojavljanja po plohama*	Average number of individuals *Prosječan broj jedinki* (ha^{-1})	Presence number of plot *Frekvencija pojavljanja po plohama*	A	B	C	D	E	F
Picea abies	tree - *drveće*	750	4	125	4	0	50	75	50	550	150
Abies alba	tree - *drveće*	11650	6	500	2	0	0	500	8600	3050	0
Pinus sylvestris	tree - *drveće*	130	2	475	2	0	200	275	50	80	0
Pinus strobus	tree - *drveće*	160	1	0	0	0	0	0	0	160	0
Larix decidua	tree - *drveće*	50	1	0	0	0	0	0	0	0	50
Fagus sylvatica	tree - *drveće*	145115	13	5450	14	0	475	4975	102015	37350	5750
Malus sylvestris	tree - *drveće*	0	0	250	3	0	150	100	0	0	0
Pyrus pyraster	tree - *drveće*	50	1	5910	10	0	870	5040	50	0	0
Quercus petraea	tree - *drveće*	35030	13	18465	26	200	4455	13810	22330	5850	6850
Castanea sativa	tree - *drveće*	13685	9	5950	17	0	1050	4900	1055	11130	1500
Aesculus hippocastanum	tree - *drveće*	0	0	50	1	0	50	0	0	0	0
Robinia pseudacacia	tree - *drveće*	0	0	725	2	125	600	0	0	0	0
Juglans regia	tree - *drveće*	1210	4	3240	17	0	1985	1255	0	160	1050
Acer pseudoplatanus	tree - *drveće*	8880	11	34735	29	400	12480	21855	810	5620	2450
Acer platanoides	tree - *drveće*	50	1	1195	6	0	150	1045	0	50	0
Fraxinus excelsior	tree - *drveće*	50	1	2125	2	0	25	2100	0	0	50
Ulmus glabra	tree - *drveće*	800	3	200	2	0	25	175	0	800	0
Ulmus carpinifolia	tree - *drveće*	0	0	1375	2	0	500	875	0	0	0
Tilia cordata	tree - *drveće*	3695	9	1830	15	0	900	930	1315	1130	1250
Carpinus betulus	tree - *drveće*	52185	13	141360	30	50	29140	112170	7135	11750	33300
Sorbus domestica	tree - *drveće*	0	0	50	1	0	0	50	0	0	0
Prunus avium	tree - *drveće*	17415	13	8825	22	30	2955	5840	8795	4720	3900
Prunus domestica	tree - *drveće*	100	2	17855	13	1350	2140	14365	0	0	100
Prunus cerasus	tree - *drveće*	0	0	275	2	0	175	100	0	0	0
Acer campestre	tree - *drveće*	12920	14	32580	30	1490	17300	13790	2680	5890	4350
Sorbus torminalis	tree - *drveće*	7480	9	2230	10	100	100	2030	4850	2130	500
Fraxinus ornus	tree - *drveće*	8435	8	17025	17	315	6570	10140	615	2470	5350
Quercus cerris	tree - *drveće*	0	0	4555	7	0	2850	1705	0	0	0
Populus tremula	tree - *drveće*	1050	2	17370	12	0	12210	5160	0	0	1050
Populus alba	tree - *drveće*	0	0	2295	2	0	150	2145	0	0	0
Alnus glutinosa	tree - *drveće*	6300	1	39610	12	400	26825	12385	0	0	6300
Alnus incana	tree - *drveće*	0	0	500	1	0	0	500	0	0	0
Betula pendula	tree - *drveće*	580	2	8910	16	1485	3100	4325	0	80	500
Salix caprea	tree - *drveće*	490	2	4805	12	0	4000	805	0	490	0
Salix sp.	tree - *drveće*	0	0	300	1	0	0	300	0	0	0
Cornus sanguinea	shrub - grmlje	5550	7	194550	34	54870	100615	39065	2850	650	1850
Crataegus monogyna	shrub - grmlje	1200	6	11545	15	2475	840	8230	250	650	300
Prunus spinosa	shrub - grmlje	350	1	34700	19	11825	19400	3475	0	0	350
Ligustrum vulgare	shrub - grmlje	4000	4	18695	18	1005	9185	8505	750	700	2550
Corylus avellana	shrub - grmlje	7675	10	41375	18	0	13000	28375	225	4850	2800
Sambucus nigra	shrub - grmlje	9910	6	11650	10	0	7225	4425	1010	7600	1300
Viburnum lantana	shrub - grmlje	1350	2	3365	5	685	1280	1400	0	1300	50
Viburnum opulus	shrub - grmlje	0	0	765	2	0	365	400	0	0	0
Berberis vulgaris	shrub - grmlje	50	1	475	2	0	425	50	0	0	50
Lonicera xylosteum	shrub - grmlje	150	1	100	1	0	0	100	0	0	150
Juniperus communis	shrub - grmlje	50	1	4140	3	0	1840	2300	0	0	50
Rosa sp.	shrub - grmlje	50	1	10685	23	2580	5850	2255	0	0	50
Frangula alnus	shrub - grmlje	0	0	2605	7	0	975	1630	0	0	0
Euonymus europaea	shrub - grmlje	0	0	3750	7	2000	1700	50	0	0	0

There was no difference in the Shannon's diversity index between the forest and abandoned land treatments (ANOVA at p<0.05; F=0.06; p=0.802) (Fig. 3). On average a little higher H' value was typical for the abandoned land treatment (1.48) and the forest treatment (1.43) (Fig. 3).

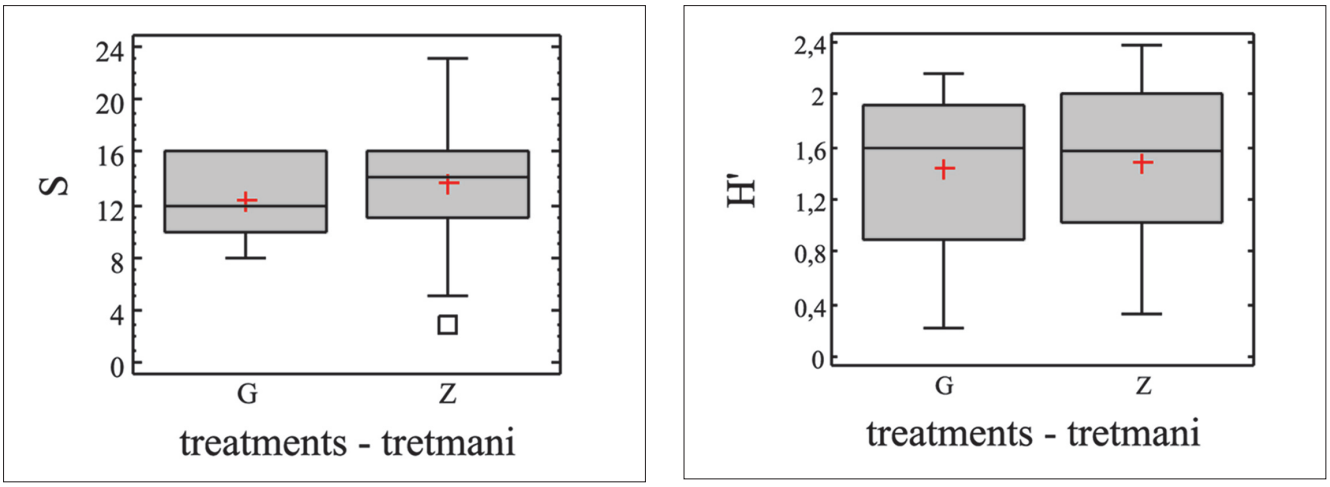

Figure 3 Box-plot of plant species richness (S) and the Shannon's diversity index (H') of treatments (Z - abandoned land, G - forest).
Slika 3. Box-plot za prosječan broj vrsta drveća i grmlja (S) za Shannonov indeks (H') po tretmanima (Z - napušteno zemljište, G - šuma).

3.3 Species composition and the density of plant species individuals between the developmental phases of forest and abandoned land – *Vrste drveća i grmlja te gustoća jedinki vrsta drveća i grmlja po razvojnim stadijima (tretmanima)*

Treatments differ in average number of all species per plot (p<0.05; F=3.09; p=0.017), in average number of tree species (F=4.95; p=0.001) and in average number of shrub species per plot (F=2.62; p=0.036) (Tab. 5).

Table 5 Mean values of the number of species between the treatments. Homogeneous groups are marked with small letters (Duncan test at p<0.05).
Tablica 5. Prosječne vrijednosti broja vrsta drveća i grmlja po tretmanima. Homogene grupe (skupine) su označene malim slovima (Duncanov test kod p< 0.05)

Treatments *Tretmani*	Count *Broj ploha*	All species *Sve vrste*		Tree species *Vrste drveća*		Shrub species *Vrste grmlja*	
		Average number per plot *Prosječan broj na plohi*	Homogeneous groups *Homogene grupe*	Average number per plot *Prosječan broj na plohi*	Homogeneous groups *Homogene grupe*	Average number per plot *Prosječan broj na plohi*	Homogeneous groups *Homogene*
A	5	7.8	a	3.8	a	4.0	abc
B	15	14.5	b	9.7	b	4.7	c
C	17	14.7	b	10.4	b	4.3	bc
D	5	11.2	ab	9.4	b	1.8	a
E	5	13.8	b	11.6	b	2.2	ab
F	5	12.0	ab	8.0	b	4.0	abc

The average number of species per plot increased with developmental phase aging on abandoned land. The number of tree species increased as well, whilst the number of shrub species did not change significantly by developmental phase aging. The average number of species in forest did not change essentially by developmental phase aging, and the average number of tree species did not change significantly as well, but the average number of shrub species increased with developmental phase aging.

There was a difference in the density of tree species individuals (F=7.46; p=0.000) and in the density of shrub species (F=6.34; p=0.000) (Tab.6).

Table 6 Mean values of the density of individuals per ha between treatments. Homogeneous groups are marked with small letters (Duncan test at p<0.05).

Tablica 6. Prosječne vrijednosti gustoće jedinki na ha, posebno po tretmanima. Homogene grupe (skupine) su označene malim slovima (Duncanov test kod p< 0.05)

Treatments *Tretmani*	Count *Broj ploha*	All species *Sve vrste*		Tree species *Vrste drveća*		Shrub species *Vrste grmlja*	
		Average number per plot *Prosječan broj jedinki* (ha^{-1})	Homogeneous groups *Homogene grupe*	Average number of individuals *Prosječan broj jedinki* (ha^{-1})	Homogeneous groups *Homogene grupe*	Average number of individuals *Prosječan broj jedinki* (ha^{-1})	Homogeneous groups *Homogene grupe*
A	5	16277.0	a	1189.0	a	15088.0	c
B	15	19612.0	a	8765.3	b	10864.7	bc
C	17	20234.1	a	14336.5	b	5897.6	ab
D	5	33087.0	a	32070.0	c	1017.0	a
E	5	21842.0	a	18692.0	bc	3150.0	a
F	5	16790.0	a	14890.0	b	1900.0	a

The density of all species individuals on abandoned land increased with developmental phase aging (Fig. 4). This pattern is reversed in forest, where the density of all species individuals decreased with developmental phase aging (Fig. 4). The findings for the density of tree species individuals were similar. On abandoned land the density of shrub species individuals decreased with developmental phase aging. There was no significant difference in the density of shrub species individuals in forest.

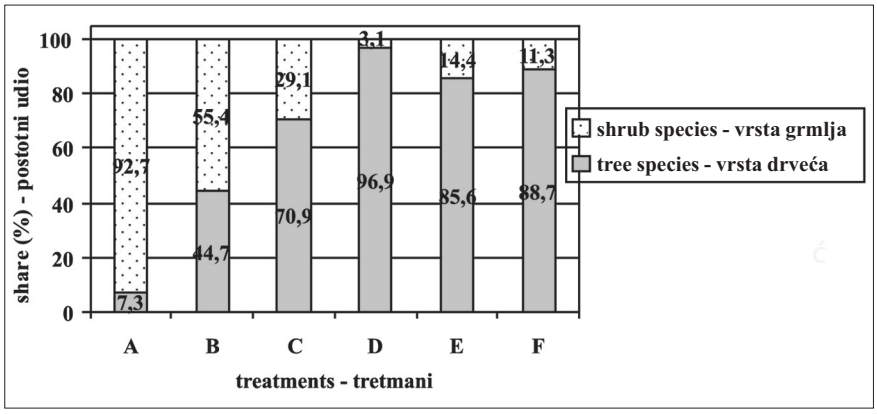

Figure 4 The density of tree and shrub species individuals per ha between treatments (A - abandoned land in young growth phase, B - abandoned land in thicket phase, C - abandoned land in pole stand phase, D - forest in young growth phase, E - forest in thicket phase, F - forest in pole stand phase).

Slika 4. Gustoća jedinki vrsta drveća i grmlja po hektaru, posebno po tretmanima (A - zemljište u zarastanju u razvojom stadiju mladika, B - zemljište u zarastanju u razvojom stadiju koljika, C - zemljište u zarastanju u razvojom stadiju letvika, D - šuma u razvojom stadiju mladika, E - šuma u fazi koljika, F - šuma u razvojnom stadiju letvika)

3.4 Overgrowing strategies on abandoned land and vegetation process in forest – *Strategija zarastanja na zemljištima u zarastanju te vegetacijski procesi u šumi*

Treatments A, B and C deal with developmental phases on abandoned land. In treatment A there was the most shrub species (Fig. 4). Thus, in young growth *Cornus sanguinea* was dominant (Tab. 4). Among tree species *Acer campestre* and *Betula pendula* were the most abundant. This is the first initial stage of shrub vegetation, which can be defined as a »*Cornus sanguinea*« stage. Shrub species still prevailed in treatment B, but their share decreased in favour of tree species. *Cornus sanguinea* thus still prevailed in the thicket stage, and was followed by *Carpinus betulus*. We can still talk about the »*Cornus sanguinea*« stage. In treatment C tree species already prevailed over shrub species. *Carpinus betulus* was abundant, while *Cornus sanguinea* was abundant in the shrub layer. The "*Cornus sanguinea*" stage in this phase was replaced by the "*Carpinus betulus"* stage.

The share of the most numerous species, *Cornus sanguinea,* strongly decreased in treatment A with developmental phase aging, whilst the share of *Carpinus betulus* increased. Shrub species were replaced by tree species in later developmental phases.

Treatments D, E and F denote initial developmental phases in forest. In treatment D there was an abundance of tree species (Fig. 4). Among the young growth prevailed *Fagus sylvatica*. *Cornus sanguinea* was the dominant shrub species (Tab. 4). In treatment E tree species still prevailed; their share was the least in this phase, but the share of shrub species increased a bit. In the thicket phase *Fagus sylvatica* still prevailed, alt-

hough its share decreased by almost a half. *Sambucus nigra* had a significant share among shrub species. Treatment F was in the pole stand phase. The tree species, whose share again increased a bit, still strongly prevailed over shrub species in this phase. The most abundant was *Carpinus betulus*. Among shrub species *Corylus avellana* had a significant share.

The share of *Fagus sylvatica*, as the most numerous species in treatment D, strongly decreased with developmental phase aging, whereas the share of *Carpinus betulus* increased. On abandoned land as well as in forest the share of *Carpinus betulus* increased with developmental phase aging.

4 DISCUSSION – Rasprava

The Haloze region has a similar trend of forest growth as Slovenia. Succession on abandoned agricultural land is influenced by numerous natural, socio-economic, infrastructural and accidental factors (Hočevar et al., 2004). The successinal process on farmland immediately starts after mowing or grazing is ceased, and in Haloze also after abandonment of vineyards and orchards. Vegetation on abandoned land develops through different stages (pioneer, middle and final stages), and proceeds in the direction of a late successional forest. Mature forest stage restoration is a long-term process that is connected with distinctive changes in species (Benabdellah et al., 2003). On the studied area Beech sites prevail, species composition changes through stages and is oriented toward beech associations ZGS, 2005a, 2005b). Only pioneer (early) stages were studied on abandoned land.

47 different species were recorded on abandoned land in the Haloze study area, of which 33 tree and 14 shrub species were found. A similar study was done in the Kočevje region (Mlinšek, 1968), where 38 species were recorded on fir-beech sites, of which 20 tree and 18 shrub species were found. If we compare the leading species, the most numerous shrub species on the Haloze hilly area is *Cornus sanguinea*, and among tree species *Carpinus betulus* prevails. In the Kočevje region the successive development inolves *Corylus avellana*, and among tree species *Populus tremula* prevails (Mlinšek, 1968). In Slovenia, as well as elsewhere in Europe and around the world, early stages on abandoned land involve different species. The succession of species immigration is different, depending mostly on the site and also on coincidence, and the immigration rate depends on the seed bank presence, soil state of preparation for germination and on the pioneer competition (Mlinšek, 1968). In the Pyrenees succession occurs with *Pinus sylvestris* (Pueyo and Begueria, 2007), but on Slovenian karst it occurs with *Pinus nigra* (Eler, 2007). The results of other studies are hardly comparable with our findings, since most of the studies deal with successive changes of herbaceous species, which were not investigated in our case, and some other studies deal only with tree species without shrub species.

In this study on abandoned land in Haloze, it was demonstrated that shrub species first appear, among which *Cornus sanguinea* is the most frequent. Shrub species represent an important ecological middle stage in forest development. In the next stage the share of shrub species decreases, and the share of tree species increases. At this developmental stage some economically significant tree species are already present. In the pole stand phase its structure and species composition are a bit more formed. At this stage tree species strongly prevail over shrub species, which have successfully completed their task and are slowly disappearing. On overgrowing land pioneer forest developed, by which site conditions are improved, since under its protection gradually other managed, shade tolerant and semi-shade tolerant species develop, and form managed forest. In later stages the share of economically significant species increases quickly (Mlinšek, 1968).

It was found that in rejuvenated gaps of forest, *Fagus sylvatica* regenerates abundantly, which is otherwise a shade tolerant species. In very good conditions it germinates in abundance, but after a few years the number of individuals decreases quickly. This is accordance with the statement by Marinček (1987), who ascertained that elimination of individuals is particularly severe in the first few years and that the number of individuals slows down later. We discovered that its share almost halves in the thicket phase (Tab. 4), yet it still prevails over other tree species. In the pole stand phase the share of *Fagus sylvatica* diminishes again. In the race for territory *Carpinus betulus* won, and *Quercus petraea* is also competitive.

The final vegetation stage is beech forest. It is thereby expected that the share of *Fagus sylvatica* will increase again in older developmental phases, and the share of *Carpinus betulus* will decrease.

5. CONCLUSION – Zaključak

Abandoned land area in the Haloze region is increasing every year. It was found that forest area in the period from 1985 to 2005 increased by 6.9 %, and it is expected to increase by another 5.5 % in the next decade.

We also found that abandoned land is a bit more diverse than forest with regard to species composition. Abandoned land differs from forest in the number of shrub species, but it does not differ in the number of

tree species. The biggest distinction in species composition was found between developmental phases within abandoned land, since pole stands are the most diverse, and the least diverse is young growth. There are also differences in the density of tree and shrub species between abandoned land and forest. In forest the density of tree individuals is higher, whilst on abandoned land the density of shrub species individuals is higher. The density of tree species individuals on abandoned land increases with developmental phase aging, but the density of shrub species individuals decreases. The opposite pattern occurs in forest, where the density of tree species individuals decreases with developmental phase aging, and the density of shrub species individuals does not change significantly with developmental phase aging.

The successinal process on abandoned farmland goes from initial "*Cornus sanguinea*" – "*Cornus sanguinea*" – "*Carpinus betulus*" stages, and vegetation process in forest from "*Fagus sylvatica*" – "*Fagus sylvatica*" – "*Carpinus betulus*" stages.

6. REFERENCES – Literatura

Baldock, D., G. Beaufoy, F. Brouwer, F. Godeschalk, 1996. Farming at the Margins: Abandonment or Redeployment of Agricultural Land in Europe. Institute for European Environmental Policy, London/The Hague.

Belec, B., 1961. Morfologija Haloz, Geografski zbornik VI, 163–190, Ljubljana.

Benabdellah, B., K. F. Albrecht, V. L. Pomaz, W. A. Denisenko, D. O. Logofet, 2003. Markov chain models for forest successions in the Erzgebirge, Germany. Ecological Modelling 159: 14–160.

Borec, A., A. Flambard, K. Pažek, 2004. Relationships between production system of Slovenian mountain farms and dynamics of overgrowing areas. Agricultura 3: 32–36.

Bračič, V., 1982. Gozdnate Haloze, Založba Obzorja, 154, Maribor.

Cunder, T., 1998. Zaraščanje kmetijskih zemljišč v Slovenskem Alpskem svetu. Sonaravni razvoj v slovenskih Alpah in sosedstvu. 1. Melikovi geografski dnevi, Kranjska gora, 5. –7. november 1998. Filozofska fakulteta, Oddelek za geografijo, 165–175, Ljubljana.

DLG, 2005. Land Abandonment, Biodiversity and the CAP. Government Service for Land and Water Management of the Netherlands (DLG), Utrecht.

Eler, K., 2007. Dinamika vegetacije travišč v slovenskem submediteranu: vzorci in procesi ob spremembah rabe tal: doktorska disertacija. Biotehniška fakulteta, Oddelek za agronomijo, 228 str., Ljubljana.

Gellrich, M., P. Baur, B. Koch, N. E. Zimmermann, 2007. Agricultural land abandonment and natural forest re-growth in the Swiss mountains: A spatially explicit economic analysis. Agriculture, Ecosystems and Environment 118: 93–108.

Golob, S., M. Hrustel-Majcen, T. Cunder, 1994. Raba zemljišč v zaraščanju v Sloveniji. Kako izboljšati posestno strukturo v Sloveniji. 9. tradicionalni posvet kmetijske svetovalne službe. Ministrstvo RS za kmetijstvo in gozdarstvo, 89–98, Bled.

Hočevar, M., G. Kušar, T. Cunder, 2004. Monitoring in analiza zaraščanja kraške krajine v GIS okolju. Zbornik gozdarstva in lesarstva 75: 21–52.

Hudoklin, J., 2004. Regional Distribution of Landscape Types in Slovenia and Outstanding Landscapes of Slovenia.

http://www.mop.gov.si/fileadmin/mop.gov.si/pageuploads/podrocja/prostor/pdf/studije/s3krajina.pdf

Klimatografija Slovenije za obdobje 1961–1990. 1995, Hidrometeorološki zavod republike Slovenije.

Kobler, A., 2001. Sprejemljivost zaraščanja kot funkcija kakovosti kulturne krajine: prostorski model: magistrsko delo. Biotehniška fakulteta, Oddelek za gozdarstvo in obnovljive gozdne vire, 187 str., Ljubljana.

Kobler, A., T. Cunder, J., Pirnat, 2005. Modelling spontaneous afforestation in Postojna area, Slovenia. J. Nat. Conserv. 13: 127–135.

Košir, Ž., 1994. Ekološke in fitocenološke razmere v gorskem in hribovitem jugozahodnem obrobju Panonije. Zveza gozdarskih društev, 149 str., Ljubljana.

Kozak, J., 2003. Forest cover change in the Western Carpathians in the past 180 years. Mt. Res. Dev. 23: 369–375.

Kozorog, E., 2004. Ali je zaraščanje kmetijskih površin problem? Gozdarski vestnik 62 (9): 407–408.

Lasanta, T., J.C. Gonzalez-Hidalgo, S.M. Vicente-Serrano, E. Sferi, 2006. Using landscape ecology to evaluate an alternative management scenario in abandoned Mediterranean mountain areas. Landscape Urban Plan. 78: 101–114.

MacDonald, D., J. R. Crabtree, G. Wiesinger, T. Dax, N. Stamou, P. Fleury, J. G. Lazpita, A. Gibon, 2000. Agricultural abandonment in mountain areas of Europe: Environmental consequences and policy response, Journal of

Environmental Management 5: 47–69.

Marinček, L., 1987. Bukovi gozdovi na Slovenskem. Delavska enotnost, 153 str., Ljubljana.

Martinčič, A., T. Wraber, N. Jogan, A. Podobnik, B. Turk, B. Vreš, V. Ravnik, S. Frajman, B. Strgulc-Krajšek, B. Trčak, T. Bačič, M. A. Fischer, K. Eler, B. Surina, 2007. Mala flora Slovenije, Ključ za določevanje praprotnic in semenk. Četrta, dopolnjena in spremenjena izdaja, Tehniška založba, 968 str., Ljubljana.

Mather, A.S., 2001. The transition from deforestation to reforestation in Europe. In: Angelsen, A., Kaimowitz, D. (Eds.), Agricultural Technologies and Tropical Deforestation. Center for International Forestry Research (CIFOR). CABI, Oxon/New York, 35–52.

Mlinšek, D., 1968. Premena grmišč v Sloveniji, 39 str., Ljubljana.

Perko, F., 2004. Gozd in gozdarstvo Slovenije. Zveza gozdarskih društev Slovenije v sodelovanju: Ministrstvo za kmetijstvo, gozdarstvo in prehrano RS: Zavod za gozdove Slovenije, 39 str., Ljubljana.

Perpar, A., 2002. Stanje in procesi v kmetijstvu v različnih tipih podeželskih območij v Sloveniji. Zbornik Biotehniške fakultete Univerze v Ljubljani. Kmetijstvo 97, 1: 281–300.

Pueyo, Y., S. Begueria, 2007. Modelling the rate of secondary succession after farmland abandonment in a Mediterranean mountain area. Landscape and Urban Planning 83 (4): 245–254.

Rickebusch, S., M. Gellrich, H. Lischke, A. Guisan, N. E. Zimmermann, 2007. Combining probabilistic land-use change and tree population dynamics modelling to simulate responses in mountain forests. Ecological Modelling 209 (2–4): 157–168.

Robič, D., M. Accetto, 1999. Pregled sintaksonomskega sistema gozdnega in obgozdnega rastlinja Slovenije. Študijsko gradivo iz fitocenologije. Biotehniška fakulteta, Oddelek za gozdarstvo in obnovljive gozdne vire, 18 str., Ljubljana.

Robič, D., 2000. Različno razumevanje in pomen biodiverzitete v ekologiji, posebno v fitocenologiji. Zbornik gozdarstva in lesarstva, 63: 47–93, Ljubljana.

Shannon, C. E., 1948. A mathematical theory of communication. Bell. System. Technol. J. 27: 379–423, 623–653.

terBraak, C. J. F., P. Šmilauer, 2002. CANOCO 4.5 for Windows – Software for canonical community ordination.

Walther, P., 1986. Land Abandonment in the Swiss Alps: a new understanding of a land use problem. Mountain Research and Development 6: 305–314.

ZGS, 2005a. Gozdnogospodarski načrt za gozdnogospodarsko enoto Rodni vrh za obdobje 2004–2015. 2005, Zavod za gozdove Slovenije, OE Maribor, 117 str., Maribor.

ZGS, 2005b. Gozdnogospodarski načrt za gozdnogospodarsko enoto Vzhodne Haloze za obdobje 2005–2014. 2005, Zavod za gozdove Slovenije, OE Maribor, 150 str., Maribor.

ZGS, 2007. http://www.zgs.gov.si/slo/gozdovi-slovenije/o-gozdovih-slovenije/slovenski-gozdv-stevilkah-2007/index.htm

SAŽETAK: Slovenija je jedna od najšumovitijih država u Europi, jer – po podacima Slovenske službe za šumarstvo (Zavod za gozdove Slovenije, 2007) – šume pokrivaju više od polovice državnog teritorija (58,5 %). Zarastanje napuštenog poljoprivrednog zemljišta šumom i dalje napreduje te tako postaje ozbiljan problem. Glavni razlog zarastanja je napuštanje poljoprivrednih imanja, ponajprije zbog teških prirodnih uvjeta te socioekonomske politike. Taj proces traje već od početka 20. stoljeća, a posebno se ubrzao nakon kraja drugog svjetskog rata.

U istraživanju smo se ograničili na područje Haloza, koje leži na području sjeveroistočne Slovenije i sastavni je dio rubnog dijela panonske nizine. Istraživanjem smo željeli proučiti koliko se poljoprivrednih površina u zadnjih dvadeset godina pretvorilo u šumu, utvrditi razlike u sastavu te gustoći jedinki pojedinih vrsta drveća i grmlja na područjima u zarastanju i u mlađim razvojnih stadijima šuma, te naznačiti strategiju zarastanja napuštenih poljoprivrednih površina uz istovremenu usporedbu sa stanjem vegetacijskih procesa u mlađim razvojnim stadijima šuma.

Istraživanjem smo utvrdili da se na području Haloza u zadnjih dvadeset godina (u razdoblju od 1985. do 2005. godine) površina šuma povećala za 6,9 %, dok u sljedećih deset godina očekujemo povećanje od 5,5 %. Vegetacijske smo popise, koje smo napravili na 52 plohe (37 ploha na poljoprivrednom zemljištu i 15 ploha unutar šume), analizirali pomoću DCA analize. Ordinacija je pokazala da pomoću prve osi, koja pojašnjava najveći dio varijabilnosti (11,6 %), možemo razlikovati dvije izrazite skupine/grupe: u prvoj grupi su plohe koje smo snimali u šumi, a u drugoj one koje smo snimali na zemljištu u zarastanju (bivšem poljoprivrednom zemljištu). Na zemljištima u zarastanju prosječno smo po plohi evidentirali 13,7 vrste, od toga je bilo 9,2 vrsta drveća te 4,4 vrsta grmlja, dok smo po plohi u šumi evidentirali 12,3 vrste, od toga 9,7 vrsta drveća te 2,7 vrsta grmlja. Na zemljištima u zarastanju broj se vrsta drveća sa starošću povećava, dok se broj vrsta grmlja bitno ne mijenja. U šumi je situacija obrnuta: staranjem razvojnih stadija povećava se broj vrsta grmlja, dok broj jedinki vrsta drveća ostaje više ili manje jednak. Veću smo gustoća jedinki zabilježili u šumi (23.906,3 jedinki po hektaru), od toga vrste drveća predstavljaju 91,5 %, a vrste grmlja samo 8,5 % svih jedinica po hektaru. Najbrojnija vrsta drveća u šumi je Fagus sylvatica*, a među vrstama grmlja* Sambucus nigra*. Broj jedinki vrsta drveća u šumi uz staranje razvojnih stadija pada, dok se broj jedinki vrsta grmlja bitno ne mijenja. U stadiju razvoja mladika glavna je vrsta* Fagus sylvatica*, u fazi koljika je najčešće pojavljuje* Carpinus betulus*. Na zemljištima u zarastanju zabilježili smo 19.447,2 jedinki po hektaru, od toga je udio vrsta drveća 53,0 % a vrsta grmlja 47,0 % svih jedinica po hektaru. Između vrsta drveća na zemljištima u zarastanju je najčešća vrsta* Carpinus betulus*, a među vrstama grmlja* Cornus sanguinea*. Na zemljištima u zarastanju udio jedinki vrsta drveća uz staranje stadija razvoja raste, a udio vrsta grmlja pada. Tako u mladiku dominiraju vrste grmlja, među kojima u cjelini dominira* Cornus sanguinea*. U razvojnom stadiju koljika njihov se udio polako smanjuje u korist vrsta drveća, no još uvijek je dominirajuća vrsta* Cornus sanguinea*, dok je na drugem mjestu* Carpinus betulus*. U fazi letvika vrste drveća već dominiraju nad vrstama grmlja. Najčešće se pojavljuje* Carpinus betulus*.*

*Proces zarastanja na bivšim poljoprivrednim zemljištima prolazi preko inicijalnih stadija "*Cornus sanguinea*"-"*Cornus sanguinea*"-"*Carpinus betulus*", a vegetacijski procesi u šumi preko stadija "*Fagus sylvatica*"-"*Fagus sylvatica*"-"*Carpinus betulus*". Konačni vegetacijski stupanj/stadiji je u oba primjera šuma bukve. U Halozama ima* Carpinus betulus *na staništima bukve (koji niže prelaze u šume bijelog graba) ulogu pionirske vrste. U starijim stadijima ponovo dominira* Fagus sylvatica*.*

Originalni STIHL lanci za pile: vrhunska kvaliteta i pouzdanost

STIHL kvaliteta razvoja: STIHL je jedini proizvođač motornih pila u svijetu koji je sam razvio svoje lance i vodilice. Na taj način se osigurava savršena usklađenost svih triju komponenti prilikom rada- pile, lanca i vodilice.

STIHL proizvodna kvaliteta: STIHL lanci izrađeni su " Švicarskom preciznošću " u STIHL tvornici u Wilu (Švicarska). Proizvode se na specijalnim strojevima koje su također razvijeni i proizvedeni od strane firme STIHL.

Vrhunska rezna učinkovitost: STIHL- ovi lanci za pile neće svoju kvalitetu i preciznost u rezanju pokazati samo na STIHL motornim pilama, nego i na pilama drugih proizvođača.

www.unikomerc-uvoz.hr

STIHL®