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Data to the changes in the structure of shrub layer in a Hungarian oak-forest ecosystem

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Abstract. New type forest decline started in 1979-80 and until now a large-scale decline of oaks appeared which had serious consequences in the structure and function of the shrub layer too. The structural parameters were recorded in the low shrub layer in a 48×48 m "A" plot in 2007 and in 2008. According to our hypothesis, it isn't expected considerably changes of the low shrub species during one year in the number of the individuals, in the proportion of the density and in the average sizes. The dominant shrubs will be remaining those species which could be able to develop policormon.

Keywords: oak forest, low shrubs, number of individuals, size changes, density

1 Introduction

Síkfőkút Project established in 1972 by Prof. Pál Jakucs from KLTE. The results and the data of the model area of a *Quercetum petraeae-cerris* oak forest ecosystem were summarized in the book "Ecology of an oak forest in Hungary. Results of Síkfőkút Project" edited by Pál Jakucs [11]. Within the framework of the "International Biological Program" and of the "Man and Biosphere" research program, complex ecosystem investigations (from 1972) launched already in various research centers abroad [16].

The "Síkfőkút Project" belongs to the Long-Term Ecological Research, that's not easy to spell putting ecological research through long time, but a project methodology with the determinate requirements and terms [23].

The cause of the changes in the forest ecosystem can be identified this decline of sessile oak in the 80s in Hungary [7, 14, 15, 24]. Serious forest declines have been reported since the early 1970's in both Central and Northern Europe and North America [2, 4, 5, 21, 34, 35, etc.]. Many hypotheses have been proposed to explain causes of the forest declines [21, 28, 33, 36]. The effects of anthropogenic factors including acid deposition, oxidants, drought, ozone and heavy metals have been examined most intensively worldwide [1, 38, 40]. There publications are focusing only to the structure, changes and dynamics of forest ecosystem.

The total measurement of shrub layer were followed in the plot of "A" (48 × 48 m) quarter-hectare of 24 hectare total research area every 4-5 years, in the course the researchers analyze the number of species and individuals, density, diversity, shrub sizes, cover of high shrub layer and thereof were doing foliage cover map. On the basis of 7^{th} and 8^{th} measuring on the shrub layer of forest established, that the decease of oaks caused considerably changes in the shrub layer. The serious decline of the oak trees (especially the sessile oak) has been started at 1979/80 in the Síkfőkút site [19, 20]. The results of 2007^{th} measurement from shrub layer were summarized in the paper of MISIK et al. [25].

So far, the surveys did not follow in two consecutive vegetation periods. Therefore, we would like to know, could be demonstrate structural changes less than one year? According to our hypothesis, it isn't expected considerably changes of the low shrub species during one year in the density, in the proportion of density and in the average sizes. The dominant shrubs will be remaining those species in the site which could be able to develop policormon. The following data were suggested important changes, which happened in the structure of oak forest ecosystem.

2 Materials and Methods

The Síkfőkút forest should be in agreement (also at the moment) with the average climazonal Hungarian turkey-oak forest [8, 31, 32]. Some studies can be found at more details from the geographic, climatic, soil conditions and vegetation of the site and the adjacent area descriptions [9, 11, 12, 13, 16, 20, 39].

The survey was done on the "A" plot in the growing season, between 06.06. and 27.06. in 2007 and between 08.07. and 16.07. in 2008, that was designated for structure surveys in 1972 [13]. Firstly, for achieving the most exact results we were studied a shrub level to splitter into low and high layer with the method from 1972 [11, 13, 19, 25]. The researchers were determined the average sizes of shrub species with a "average shrub" random method [16]. We measured the height with a tape-measure and the shoot diameter at 5 cm height above the soil with a slide caliper (to average sizes used random methodology).

The root-studies [17, 18] were confirmed that one part of the shrubs composes policormon (especially *Euonymus verrucosus*, *Euonymus europaeus*, *Ligustrum vulgare* and *Cornus sanguinea*) so the number of shoots above the soil are not the same as the number of individuals [19]. Also, the number of sprout counted by researchers at the measuring, but the number of individuals was used throughout in our study (except a chapter of diversity and evenness).

3 Results and discussions

On the sample area lived 16 and 17 low shrub species in 2007 and in 2008. We were counted together 9495 individuals and 10511 individuals one year later in the "A" quarter-hectare. *E. verrucosus* gave about 56.00% and 48.00% of all the low shrubs in both measuring times, so he was the dominant shrub species.

Following that were *E. europaeus* 10.60% and *Ligustrum vulgare* 10.00% occurence frequency in year 2007. On the next measuring haven't been changed the succession, only the rate of frequency of shrub species. The occurrence frequency of other low species was lower with an order of magnitude. The rate of *Quercus* seedlings (*Q. petraea, Q. cerris* and *Q. pubescens*) were a quite small, referring to hectare it was 5.10% and 5.60% of all low shrubs in 2007 and in 2008, and Q. petraea was the dominant here with rate of 3.90% and 4.10%. It should be mentioned that the oak seedlings showed remarkably fluctuation from year to year. The measured data are summarized in Table 1 and can be found in the study of MISIK et al. [26].

We were making density maps from low shrub layer. Figure 1. shows the density of low shrub layer and shows considerably changes between 2007 and 2008. In the last about three decades the number of *Quercus* seedling showed considerably fluctuation from year to year so we did not consider them on the density map.

Table 1: The number, rate and changes of shrub individuals per low shrub layer

Name of species	Piece/"A" quadrat		Piece/ha		%	
	2007	2008	2007	2008	2007	2008
Acer campestre	544	539	2361	2339	5.73	5.13
Acer tataricum	280	346	1215	1502	2.95	3.29
Cerasus avium	172	178	746	773	1.81	1.69
Cornus mas	117	99	508	430	1.23	0.94
Cornus sanguinea	388	392	1684	1701	4.09	3.73
Crataegus monogyna	155	160	673	694	1.63	1.52
Euonymus europaeus	1006	2034	4366	8828	10.60	19.35
Euonymus verrucosus	5292	4995	22967	21678	55.74	47.52
Juglans regia	15	15	65	65	0.16	0.14
Ligustrum vulgare	953	1104	4136	4791	10.04	10.50
Lonicera xylosteum	22	37	95	161	0.23	0.35
Quercus cerris	42	69	182	299	0.44	0.66
Quercus petraea	370	430	1606	1866	3.90	4.09
Quercus pubescens	109	88	473	382	1.15	0.84
Rhamnus catharticus	14	5	61	22	0.14	0.05
Rosa canina	12	16	52	69	0.12	0.15
Tilia cordata	4	4	17	17	0.04	0.04
Summa	9495	10511	41207	45616	100.0	100.0

The lowest shrubs developed in 2007 in small quadrates "d5", "f2" and "k12" with 4–4 pieces, one year later were found in "m11" and like to 2007 in "f2" the lowest individuals with 4 and 5 pieces. The number of low shrubs was the biggest in "m5", "d1" small quadrate with 289 and 263 individuals, one year later in "d1", "h8" parcel with 364 and 302 individuals. Comparison of the density trends showed that the low shrubs exceeded the 200 pieces limit of individuals only in one small quadrate, but in 2008 were found already 4 small 4×4m quadrates with more than 200 individuals.

The "A" plot shrub density conditions are not necessarily typical for the whole of the forest stand, because the dying *Q. petraea* and *Q. cerris* trees were issued in different sizes foliage gaps on the "A", "B", "C" and "D" quarter-hectare of the sample area [11, 19, 22].

The low shrubs (among 0.50–1.00 m height) of the forest can be divided into shoot, crown and root similarly to the trees. The directly branch is not

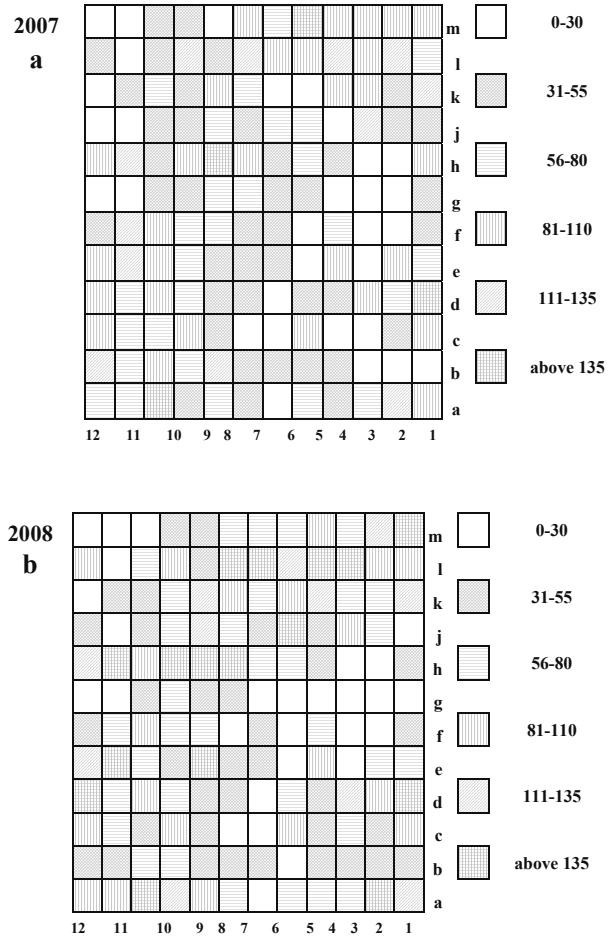

Figure 1: Density of low shrub individuals in small quadrates of the "A" quarter-hectare area in 2007 (a) and in 2008 (b)

typical above the ground surface. Following our measurement of year 2007 and in 2008 the low shrubs were reached 0.32 m and 0.29 m average height. The average trunk (shoot) diameters of low shrub layer were 0.42 cm and 0.35 cm. The biggest low shrub species were based on the average height and shoot diameter *Tilia cordata* and followed them a *Lonicera xylosteum* and *Rhamnus catharticus*. However, these shrub species were presented only small individuals in the plot of research area. The smallest mean values were measured by individuals of *A. campestre* and *E. europaeus* in 2007.

Also in the 2008th survey were reached the greatest average height a 4 specimens of *T. cordata* with 0.53 m, followed them a *L. xylosteum* and *Crataegus monogyna* individuals with 0.52 m and 0.42 m average heights. The researchers were measured the biggest average shoot diameter of "A" sample area by individuals of T. cordata with 0.80 cm, followed them *Cr. monogyna* with 0.64 cm, then *L. xylosteum* with 0.52 cm mean diameter. In point of the dominant shrub species on the sample area have got already other picture. Among of them both in 2007 and in 2008 had got the biggest average sizes a *Cornus mas* and *C. sanguinea*, or rather a *Cr. monogyna*, while *Acer campestre*, *A. tataricum* and *Euonymus sp.* to least were grown.

Only by comparison, on the beginning of the measurements the lower part of the shrub layer below 1 m (low shrub layer) reaches 0.32 m average height. The average trunk diameters of the low shrub layer (the shoot thicknesses) are 0.34 cm [11]. The average sizes are shown in Table 2.

Table 2: Average shrub sizes of the low shrub layer in 2007 and in 2008

Name of species	Height (m)		Shoot diameter (cm)		Measured individuals (pc)	
	2007	2008	2007	2008	2007	2008
Acer campestre	0,16	0,23	0,29	0,34	40	64
Acer tataricum	0,27	0,25	0,33	0,25	32	68
Cerasus avium	0,22	0,20	0,32	0,21	35	24
Cornus mas	0,40	0,40	0,54	0,50	41	32
Cornus sanguinea	0,38	0,40	0,37	0,39	40	66
Crataegus monogyna	0,37	0,42	0,54	0,64	57	60
Euonymus europaeus	0,16	0,16	0,34	0,25	52	118
Euonymus verrucosus	0,29	0,34	0,40	0,40	99	169
Juglans regia	0,33	0,28	0,40	0,23	5	10
Ligustrum vulgare	0,36	0,31	0,49	0,36	52	89
Lonicera xylosteum	0,57	0,52	0,65	0,52	11	16
Quercus cerris	0,15	0,13	0,26	0,19	4	14
Quercus petraea	0,18	0,18	0,30	0,28	60	84
Quercus pubescens	0,15	0,11	0,23	0,19	10	26
Rhamnus catharticus	0,51	0,25	0,50	0,16	4	3
Rosa canina	0,37	0,18	0,32	0,19	7	8
Tilia cordata	0,58	0,53	0,85	0,80	4	4
mean	0,32	0,29	0,42	0,35	32	50

In recent years, some studies have shown that only some Quercus seedlings could be grow above 25 cm height in the site, and the number of seedlings lower from this value decreases from year to year [24].

The biggest average cover value was measured by individuals of *T. cordata* with 1155.00 cm^2 in 2008, followed them *L. xylosteum* with 1119.13 cm^2 foliage cover and *Juglans regia* with 1066.20 cm^2 average cover value. However, these shrub species were lived only with small individuals in the year of research. Among the dominant low shrub species were measured biggest mean cover values by *L. vulgare* and by *C. sanguinea* with 435.27 cm^2 and 611.97 cm^2 parameters. The smallest cover values had got *Q. pubescens* and *E. europaeus* with 80.58 cm^2 and 95.04 cm^2 foliage cover. Among the determining shrub species on the site the individuals of *Acer sp.* and *Euonymus sp.* have got characteristically small cover values. The researchers were measured the total cover value with the cover of all individuals of shrub species of low shrub layer in the sample area ("mean cover values × number of individuals" for each species) and this value was 2668.54 m^2, so in 2008 in the plot of "A" 48×48 m (2304 m^2) quarter hectare were measured 115.82% simplification cover value, this is the area, which covered all living low shrub individuals. These detailed values for the every shrub species in the study area are shown in Table 3.

Finally we were summarized the most important results. On the sample area lived 16 and 17 low shrub species in both measuring with 9495 and 10511 individuals. *E. verrucosus* was the dominant shrub species about 56.00% and 48.00% of all the low shrubs. The rate of *Quercus* was a quite small in every year. The lowest shrubs were found in 2007 in 3 pieces small quadrats with 4–4 individuals, one year later were found 2 quadrats with 4 and 5 individuals. The number of low shrubs was the biggest in 2-2 small quadrat with maximum 289 and 263 individuals, one year later with 364 and 302 individuals. Following our measurement of year 2007 the low shrubs were reached 0.32 m average height. The average trunk (shoot) diameters of low shrub layer were 0.42 cm. One year later this average parameters were decreased with a small-scale. We were measured 502.97 cm^2 mean foliage cover value in 2008. The smallest cover values had got *Q. pubescens* and *E. europaeus*.

Table 3: Average foliage cover values of the low shrub layer in 2008

Name of species	Foliage cover (cm^2)	Measured individuals (pc)	Total cover (m^2)
Acer campestre	332.71	250	179.33
Acer tataricum	382.35	200	132.28
Cerasus avium	291.30	50	51.85
Cornus mas	758.00	40	75.04
Cornus sanguinea	611.97	200	239.90
Crataegus monogyna	882.94	50	141.26
Euonymus europaeus	95.04	350	19.32
Euonymus verrucosus	236.53	350	1181.32
Juglans regia	1066.20	10	15.99
Ligustrum vulgare	435.27	350	480.57
Lonicera xylosteum	1119.13	15	41.41
Quercus cerris	235.05	20	16.22
Quercus petraea	187.00	200	80.41
Quercus pubescens	80.58	50	0.71
Rhamnus catharticus	235.80	5	1.18
Rosa canina	445.60	5	7.13
Tilia cordata	1155.00	4	4.62
mean	502.97	126	156.97

4 Conclusion

The research involved studies on the potential causes of the sessile oak decline, which was reported throughout Hungary (climate change, acidic rain, soil conditions changes, toxic elements etc.) [7, 10, 15]. This procession is not incomparable in the world. Different studies report the decline of various oak forests, the causes of mortality and not least the take placed processing in the forest ecosystem [3, 6, 27, 29, 30, 37, 41]. We are focusing to the cause of the the low shrub layer changes in the forest ecosystem after the decline of sessile oak. The results suggest the following main conclusions: the number of species in the "A" plot sample area did not changed less than one year. Those species lived with a significant number of individuals, which could be able to develop policormon, for example *Euonymus sp.*, and *L. vulgare*. The number of *Quercus* seedlings did not changed considerably compared to year 2007. The Quercus seedlings could not appear in the shrub layer and the rate of these seedlings were a quite small. According to our measurements, only

some *Quercus* seedlings (especially *Q. petraea*) were reached or exceed the 30 cm height limit, and the biggest individual was 39.60 cm in 2007.

We could not find important changes in the data of average height and the shoot diameter of species. In contrast, in the number of individuals and the shrub density conditions of the 4×4 m small quadrates of the "A" plot over a period of one year measured already considerably changes.

This is good exemplify that the number of individuals increased by more than 1000 individuals from 2007 to 2008. The *E. europaeus* had got a privileged role in the increasing of the number of individuals.

Moreover, about 60% of the small quadrates shifted into a different density category during one year. This is good exemplifying that 84 of the total of 144 small quadrates (58.33%) shifted into a different density category during one year. In addition, the important realignment of a density conditions is not only a direct consequently of the ascendant number of individuals, because we found some small quadrates, wherein under one year were decreased the number of individuals. Importantly, it was found that in 2008 were increased the number of the quadrates, where more than 111 or 135 low shrub individuals per small quadrates lived.

However in terms of density conditions remarkably realignment was occurred. This is the most important change in the research area between 2007 and 2008. From these data we could draw a far-reaching conclusion, if we analyze in detail the weather conditions of the related years. However, we have no more possibility to analyze more details within the available extension of this paper.

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