UNDERSTORY FOLIAGE COVER IN AN HUNGARIAN OAK FOREST IN 2012

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Abstract: The serious oak decline was reported for the 1979–80 period and 63.0% of adult oaks died in a mixed oak forest in the Síkfőkút site, in the north-eastern part of Hungary. The data were used to obtain (1) quantitative information on shrub canopy, including foliage cover percentage of the shrub layer, mean cover of shrub species in 2012; (2) structural information on shrub foliage arrangement and (3) true description from the present ecological condition of the subcanopy layer. In the monitoring plot, the foliage cover condition of specimens only above 8.0 m was observed in 2012. The data relating to the projected foliage areas of high shrubs have been evaluated and foliage map waas digitized in ArcGis. It was measured a very low value of the foliage cover. The shrub layer cover was 61.5%, the duplex- and multiplex was 13.1% and only 76.8% total foliage cover in the understorey. The mean cover of the shrub species changed between 0.5 m^2 and 6.4 m^2 in the high shrub layer. The maximum mean cover values were recorded by the dominant woody species (*Acer campestre*, *Acer tataricum* and *Cornus mas*) in the shrub community. The GIS analysis confirmed that total foliage cover of the subcanopy layer and of the higher dominant woody individuals was 522.4 m^2. Our results suggest that the foliage cover size of shrub layer was a very low in 2012 and was measured similar low mean cover values of shrub species.

Keywords: ArcGis, shrub layer, *Acer campestre*, mean cover, shrub foliage cover, georeferencing

INTRODUCTION

Numerous studies used different structural variables, biotic and abiotic indicators to long-term detect and monitor the forests health and dynamics (Jukola-Sulonen *et al.* 1990; Strand 1995; Wicklum and Davies 1995). Several biotic and abiotic factors have been considered as important in forest health studies, such as

extreme weather conditions, drought, storms, heat (Drobyshev *et al.* 2008; Bolte *et al.* 2010), and insect fluctuations (Moraal and Hilszczanski 2000), disease outbreaks (Mistretta 2002) or human induced influences such as climate change, air pollution and fires (Signell *et al.* 2005; Kabrick *et al.* 2008). These factors may modify the functioning of the whole forest ecosystem and may lead to tree decline events.

The tree decline has heavily affected oak species and especially *Quercus petraea* Matt. L. (sessile oak) trees in European countries and naturally in Central Europe (Freer-Smith and Read 1995; Führer 1998; Thomas and Büttner 1998). An increasing decline of oak forests has been observed in many regions of Hungary since 1978. The oak decline in Slovakia began in 1976, in former Yugoslavia in 1979 and finally reaching the eastern regions of Austria in 1984 (Hämmerli and Stadler 1989). The stand dynamics of oak forests in Europe has been a topic of interest and concern to resource managers and scientists in the last period. Many studies have examined the effects of tree decline on stand (especially on canopy layer) development but relatively few research papers deal with shrub community and shrub layer dynamics in the process of tree decline (Alaback and Herman 1988; Gracia *et al.* 2007; Gazol and Ibáñez 2009).

Different structural variables can be used as indicators of disturbance regime and management practices in forests (Zumeta and Ellefson 2000; Larsson and Danell 2001). These variables are among others cover. Open areas and tree species diversity had a positive relationship to shrub cover because a diverse overstorey generally created more canopy gaps (Gazol and Ibáñez 2009). Canopy layer stand structure strongly influences understorey cover by resources, altering microsites and environmental conditions by light availability (Alaback 1982; Oliver and Larsson 1996). Shrub cover is linked to habitat quality and a number of interconnected ecological processes (Carey 1995; Hagar *et al.* 1996).

The species composition of the canopy layer was stable until 1979 and the healthy density of *Q. petraea* and of *Quercus cerris* L. (Turkey oak) also remained constant in the study site. The massive dieback of oaks started in 1979–80 and 68.4% of *Q. petraea* trunks died until 2007. The oak decline of the sample site resulted in an opening of the canopy. The overall species composition of the canopy has changed little, only some trees of *Tilia cordata* Mill. and

Carpinus betulus L. lived as new species in the site. The results of Jakucs (1988) suggested that the soil acidification induced by disappearance of mycorrhiza fungi and the air pollutants that promote water and nutrient absorption have been considered and identified as primary causes of deciduous forest decline.

Most papers only used changes in structural conditions in the tree layer to monitor the ecological process in the forest community after tree decline (Bussotti and Ferretti 1998; Brown and Allen-Diaz 2009). The studies of shrub species performed have mostly focused on the static population structure (age and size structures) (Tappeiner *et al.* 1991; Stalter *et al.* 1997). Other studies have focused on the cover and diversity of shrubs (Kerns and Ohmann 2004; Gracia *et al.* 2007). The decreased oak tree density led to numerous significant structural changes in the understorey such as herbaceous layer and shrub layer. The objectives of this study were to (1) give quantitative information on shrub canopy, including foliage cover percentage of the shrub layer, mean cover of shrub species in 2012; (2) describe structural information on shrub foliage arrangement and finally (3) give description from the present ecological condition of the subcanopy layer.

MATERIAL AND METHODS

Study site
The 27 ha reserve research site is located in the Bükk Mountains of northeast Hungary (47°55′ N, 20°46′ E) at a distance of 6 km from the city of Eger and at an altitude of 320–340 m a.s.l. The site was established in 1972 by Jakucs (1985) and has been used for the long-term study of forest ecosystems. The mean annual temperature is 9.9°C and mean annual precipitation typically ranges from 500 to 600 mm. The mean annual temperature and precipitation are based on measurements at the meteorological recording tower of the site. Descriptions of the geographic, climatic, and soil conditions, and vegetation of the forest were reported in detail by Jakucs (1985, 1988). Paper of Koncz *et al.* (2011) showed the seed bank and herbaceous vegetation condition of the forest. The most common forest association in this region is sessile oak and Turkey-oak forest community (*Quercetum petraeae-cerris*) with a dominant canopy of *Q. petraea* (sessile oak) and *Q. cerris*

(Turkey oak) deciduous tree species. Both oak species are important dominant native deciduous tree species of the Hungarian natural woodlands. Other codominant tree species in the site included *C. betulus*, *Prunus avium* L. and *T. cordata*. The plots under study were made up of evenly aged temperate deciduous forest trees that were at least 100 years old and had not been thinned for more than 50 years.

Sampling and statistical analysis
The necessary data of shrub layer condition has been collected at a definite period on a 48 m × 48 m monitoring plot. The permanent subplots (4 m × 4 m) were established in 1972. The data were obtained from a 24ha study site at regular intervals within the site. The investigations were performed during the growing season in 2012.

Canopy trees were classified as sessile oak and Turkey-oak tree species > 13.0 m in height and ≥10.0 cm in diameter at 1.3 meters above ground (dbh). Shoot height and shoot diameter of the shrub individuals were the two main variables recorded. Specimens which were higher than 1.0 m were categorized as high shrub. The lower specimens were categorized as low shrub. Stems < 50.0 cm height of oak species were inventoried and identified to oak seedlings. The term "dominant woody" is used to refer to *A. campestre*, *A. tataricum* and *C. mas* species that play a key role in an understorey based on the high densities and largest mean sizes for the shrub community.

The following measurements were carried out in each subplot: was detected foliage cover percentage and mean cover condition of high shrub individuals. In 2012 were sampled 486 high shrub individuals and then subjected to the mean cover analysis of shrub species. Box plot method used for graphically depicting groups of shrub's foliage cover data through their quartiles. Foliage cover, duplex- and multiplex cover (shrub canopy overlapped other shrub species) of the high shrub layer and total cover of the all high shrub individuals were also recorded. Location and cover of all high shrub specimens were mapped in each subplot. A projected foliage area cartogram of high shrubs was prepared using a method described in several studies (Jakucs 1985; Misik *et al.* 2007). Since 2012, data relating to the projected foliage areas of high shrubs have been evaluated and foliage map waas digitized in ArcGis. ArcGIS is a

geographic information system (GIS) for working with maps and geographic information in our study site. After the scanning, in the sample site was surveyed 24 pieces hand drawn segments and these segments were georeferencing on the basis of the cardinal gps coordinates to the EOV coordination system. On the basis of the delineated foliage margin on the georeferenced segments we vektorized all living individuals of the shrub species in the monitoring plot. Territorial and circumferential data belonged to the all shrub individuals. The total cover of the understorey was recorded on the basis of the contraction of the all polygon. The foliage cover overlapes of the shrub layer was determined by means of the "Intersect" ArcGIS tool. The distributed georeferring, digitalization and the actions of the geographical information system was making with the ArcMap 10.4 geographical information software. Based on the digitized map we estimated the foliage area of shrub species with the GIS environment.

RESULTS

In 2012, 11 native woody species were identified across the entire study area in the high shrub layer; *Acer campestre* L. (field maple), *Acer tataricum* L. (Tatar maple), *Cerasus avium* L. (wild cherry), *Cornus mas* L. (European cornel), *Cornus sanguinea* L. (common dogwood), *Crataegus monogyna* Jacq. (common hawthorn), *Euonymus europaeus* L. (common spindle), *Euonymus verrucosus* Scop. (warted spindle), *Ligustrum vulgare* L. (common privet), *Lonicera xylosteum* L. (fly honeysuckle) and *Tilia cordata* Mill. (small-leaved linden) were present as high shrub species in the sample site. It was determined the foliage cover sizes of these species.

In 2012 was measured a very low size of the foliage condition. The shrub layer cover was 61.48%, the duplex- and multiplex cover was 13.11% and was recorded only 76.83% total foliage cover in the understorey. This dataset was the lowest from the starting of the measurements (*Table 1*).

Table 1. Foliage cover condition in the understorey shrub layer in 2012 and between 1972-2007 period in Síkfőkút.

year	foliage cover (%)	duplex and multiplex cover (%)	total cover (%)
2012	61.48	13.11	76.83
1972-2007	77.57	41.47	129.53
mean	69.53	27.29	103.18

The mean cover of the shrub species individuals changed between 0.54 m² and 6.39 m² in the high shrub layer. It was measured 4.29-6.39 m² mean foliage cover by the dominant woody species of the shrub community. The highest cover values were detected for a single *C. avium* and single *T. cordata* tree species with 12.98 m² and with 11.12 m² under the oak canopy layer (*Table 2*).

Table 2. Mean foliage cover (±S.D.) of the species in the understorey shrub layer in 2012.

species	measured individuals number	cover (m²)	S.D.
Acer campestre	133	6.12	6.10
Acer tataricum	22	4.29	3.24
Cerasus avium	1	12.98	0.00
Cornus mas	85	6.39	4.52
Cornus sanguinea	29	0.54	0.65
Crataegus monogyna	47	2.19	2.19
Euonymus europaeus	10	1.42	1.62
Euonymus verrucosus	142	1.06	1.15
Ligustrum vulgare	14	0.73	1.72
Lonicera xylosteum	2	0.87	0.68
Tilia cordata	1	11.12	0.00

Box plot showed the cover distribution of high shrub species individuals in 2012. The median cover value of *C. mas* was the maximum; the lowest values were recorded by *C. sanguinea*, *E. verrucosus* and *L. vulgare*. The maximum standard deviation of cover values were detected by *A. campestre* individuals. Many field maples reached the tree size; the cover dataset was confirmed this statement (*Figure 1*).
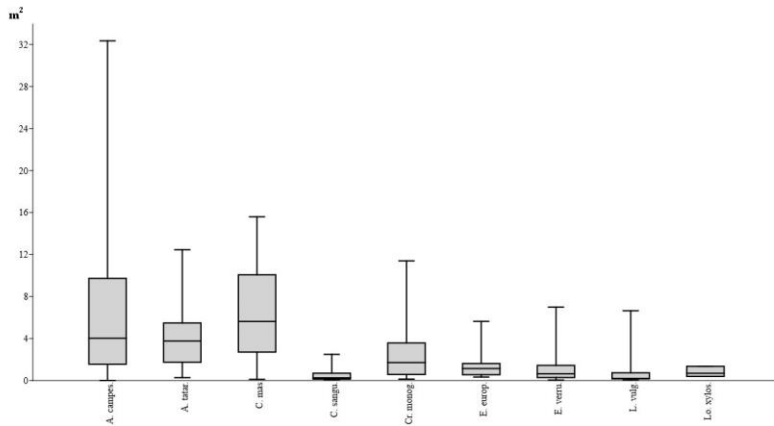
Figure 1. Statistical summary of cover sizes distribution of high shrub species on the monitoring plot in 2012. Boxes shown are the 25–75% percentile, median, minimum and maximum values (N = 486). (Notation: A. campes. = *Acer campestre*; A. tatar. = *Acer tataricum*; C. mas = *Cornus mas*; C. sangu. = *Cornus sanguinea*; Cr. monog. = *Crataegus monogyna*; E. europ. = *Euonymus europaeus*; E. verru. = *Euonymus verrucosus*; L. vulg. = *Ligustrum vulgare*; Lo. xylos. = *Lonicera xylosteum*)

In the subcanopy layer (between 8.0-13.0 m), and above this layer 3 dominant woody species were identified across the entire study area: *A. campestre*, *A. tataricum* and *C. mas*. The field maple was the dominant species with 53 individuals in the subcanopy and tree layer of the study site. The GIS analysis confirmed that total foliage cover of the subcanopy layer and of the higher dominant woody individuals was 522.38 m². Mean cover of *A. campestre* individuals was 8.26 m² in the subcanopy and tree layer; it was measured 3.47 m² and 11.61 m² mean foliage cover values by *A. tataricum* and *C. mas* individuals. The *C. mas* individuals has got the biggest mean foliage cover in the subcanopy layer. Above the 8.0 m height limit, the field maple is the dominant species, because nearly 84.0% percent of the total cover has got own individuals. It was found single *C. avium* and single *T. cordata* tree individuals in the subcanopy (*Table 3*).

Table 3. Mean (±S.D.) and total foliage cover of the woody and tree species individuals in the subcanopy layer in 2012.

species	mean cover (m²)	S.D.	total cover (m²)	density (ind. ha⁻¹)
Acer campestre	8.26	6.22	437.97	230
Acer tataricum	3.47	2.21	13.89	17
Cerasus avium	12.98	0.00	12.98	4
Cornus mas	11.61	5.59	46.42	17
Tilia cordata	11.12	0.00	11.12	4
sum	-	-	**522.38**	**272**

DISCUSSION

Nowińska (2010) examined the ecological impact of canopy and canopy gaps on the development of lower forest layers in five protected phytocoenoses of oak-hornbeam habitats (natural and regeneration stands) and oak-pine habitats in the Wielkopolska National Park of Western Poland. Foliage gaps do not affect bryophyte richness and cover. The impact of gaps on the herb layer is not uniform for the investigated forests. Gaps often, though not in all cases, cause a significant increase in the total herb layer cover, vascular antrophophyte cover, vascular species richness and a greater Shannon diversity. In our site In the study of Gracia *et al.* (2007) the relationship between shrubs cover and basal area of overstory was only significant for two species, and in both two cases, cover decreased with basal area. Other studies have shown negative correlations of understory cover with canopy trees basal area (Gilliam and Turrill 1993) presumably because of differential light availability.

Tree species influenced shrub, herb and moss cover size (Klinka *et al.* 1996). Results from Kerns and Ohmann (2004) suggest that forest community structure, stand development, site disturbance history and environment all interact to influence shrub layer cover in Oregon landscape. Shrub cover was negatively correlated with *Tsuga heterophylla* basal area and density of shade tolerant tree individuals. Total shrub cover increased significantly ($P < 0.001$) with time since canopy gaps. Furthermore, the increase in total species foliage cover was significantly more pronounced in mature than old-growth stands of Canada (De Grandpré *et al.* 2011). Total

cover of the understory shrub layer increased slightly, but nonsignificantly in a mature oak forest of USA, from 45.0% in 1950 to 51.0% in 1969 and 1979.

Misik *et al.* (2013) reported that in the studied oak forest the shrub layer foliage cover increased remarkably from 1972 to 1988; since 1993 onwards there has not been a clear tendency in the change of the shrub layer cover. No significant differences were revealed between oak tree density and duplex- and multiplex cover in the shrub community (P > 0.05). *A. campestre* individuals showed a significant mean percent cover increase (P ≤ 0.05) after serious oak decline. Besides than higher foliage cover was recorded by *C. mas* and *A. tataricum* species 6.4 and 4.5 m^2 mean cover. In our present study the cover size in the understory showed an important decreasing in the last five years. The most important reason of the foliage decrease was the weather condition, because the summer was very hot and extreme dry in 2012 (Sippel and Otto 2014).

CONCLUSIONS

In 2012 was measured a very low size of the foliage condition. The shrub layer's cover size dataset was the lowest from the starting of the measurements, from 1972. The mean cover of the shrub species individuals changed between 0.54 m^2 and 6.39 m^2 in the high shrub layer. The dominant woody species of the shrub community have got the maximum mean foliage cover with 4.29-6.39 m^2 values. The median cover value of *C. mas* was the maximum; the lowest values were recorded by *C. sanguinea*, *E. verrucosus* and *L. vulgare* species individuals. The maximum standard deviation of cover values were detected by *A. campestre* individuals and many field maples reached the tree size. The GIS analysis confirmed that total foliage cover of the subcanopy layer and of the higher dominant woody individuals was 522.38 m^2. The cover dataset in the shrub community was a very low in 2012 and showed considerably decreasing compared with the last three decades cover values.

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