THE *LICHENOINDICATIVE* EVALUTION OF OAK WOODLAND KEY HABITATS

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Abstract

This article presents the description of oak woodland key habitats and their importance in the maintaining of biodiversity as well as a necessity of management and monitoring. The lichens *Lichenes* and its percental cover features have been described. The exposition of lichen species depending on the cardinal points have been analysed. The article presents the characteristics of ecological indicators of lichens in the objects. The lichenoindicative evaluation and comparison of oak woodland key habitats in Latvia have been carried out.

Keywords: lichens epiphytes, oak woodland key habitats, giant trees, management of woodland habitats.

Introduction

Oak (*Quercus robur* L.) is a common broadleaved tree species in Europe which spread into Latvia 6000 years ago and in some regions it made up to 40% of forests. 1500 years ago broadleaved – spruce forests prevailed over the whole territory of Latvia. However, the demand for wood, the suitability of the land to cultivation and uncongenial climate changes were the reasons why the number of oaks was decreased. As a result, in the present structure of forests in Kurzeme and Zemgale only a few oak stands remain. In Vidzeme oaks can be found growing among other trees (Priedītis, 1999; Strods et al., 1999). Giant oak trees are biologically old and huge growing solitary or in forests. They have a wide-spread crown. They serve as a substratum and habitat for many rare and threatened species of epiphytic lichen, insect and fungi species that live in the wood of trees. A part of these species are used as a woodland key habitat indicator species (IS) and habitat specialist species (SBS). The presence of IS and SBS is a sign that determines the woodland key habitat (WKH) status for the tree (Ek et al., 2002; Bērmanis, Ek, 2003). According to the conditions of growing and developing conditions, the trees can be divided into the trees growing in the shade and those growing in an open landscape, for instance, on agricultural lands. In order to provide a habitat for an oak related SBS, different management techniques have to be used to giant trees growing in different conditions. The origin of the tree is evaluated according to the history of the land use in the respective location (the age and the structure of the surrounding stand), tree structure (the shape of a crown and branches, the depth of cracks in the bark) and the species of epiphyte on the tree (Johansson, 2005; Johannesson, Ek, 2005). A typical feature of the trees that had previously been growing in a shade (in a forest stand) is a gap disturbance dynamics – as a natural type of a natural disturbance. They do not need management or as an alternative to cutting the girdling of those trees which are intergrown into the crown of the oak. The broadleaved trees which had initially grown in a more open landscape, for instance, in a forest meadow or on pastures, as well as the living organisms which are found on them, are adapted to brighter light. It is believed that in the course of evolution they have been formed by big herbivores (bisons *Bison bonasus* L., wild horses *Equus ferus ferus* Boddaert, aurochs or urus *Bos taurus* L.) which, due to their natural habits (gnawing, grazing) have maintained a partly open landscape (Vera, 2000). On the whole, in open and partially open habitats the number and diversity of species connected with giant oaks is higher. Such trees need to be carefully and gradually released from the shade. That should be done in the same course of time as it took the shade to be formed. The older the tree and the longer it had grown under such conditions, the more sensitive it is to changes (Read, 2000; Johansson, 2005). In order to successfully preserve the characteristic species of

the later stage of the tree development in the habitat, it is necessary to have the trees of the same species of different ages around. Maintaining and carrying out management activities, the future giant trees have to be chosen (Ek et al., 2002; Johansson, 2005).

In the inventory of natural woodland habitats lichen is one of the group of organisms which is used to evaluate the biological diversity and forest continuity (Ek et al., 2002; Znotiņa, 2003). Lichen is an organism whose development and growth depends on phytocenotic and ecological conditions in the stand (Sõmermaa, 1972). In the last decades considerable attention has been paid to the research of interdependence of lichen diversity and forest management (Nash, Wirth, 1988; Sillett, Goslin, 1999; Van Herk, 1999; McCune, 2000; Will-Wolf et al., 2002) which has a direct influence on the lichen epiphyte communities and their development (McCune, 2000; Will-Wolf et al., 2002; Lõhmus, 2005). Lichen monitoring is especially important for evaluating the environmental changes, especially in relation to natural habitats that play a great role in preservation of biological diversity (Piterāns, Žeiviniece, 2000; Donis et al., 2004; Bērmanis, 2006).

The aim of the research is to describe and evaluate the woodland key habitats – giant oak trees from the lichoindicative point of view. In order to reach the goal, the following objectives have been set:

1. Lichens and the analysis of its cover in percentage in oak woodland key habitats;
2. The description and analysis of dependence of lichen exposition on cardinal points;
3. The description of lichen ecological indicators.

Materials and Methods

In order to carry out the lichenoindicative analysis in oak woodland key habitats, nine research sites were chosen in 2005 in Latvia (Table 1). Seven - eight sample plots were made depending on the number of giant oak trees (Donis et al., 2004). In total 70 oaks were measured. The age of oaks according to the inventory data is within the limits of 126 (in site 1) to 228 years (in site 6). The age of the forest stands according to the inventory data is shown in Table 1.

The record of lichens on oak trees is made clockwise (N – E – S – W), using the line method

Table 1

The description of the research sites

Site code	State Head Forestry (SHF)	State Forestry (SF)	Compartment/ sub-compartment	Stand composition, age	Forest type
1	Sēlija	Viesīte	364/ 13	$3E_{32}4E_{27}2Oz_{32}1Oz_{126}$	Oxalidosa
2	Aizkraukle	Nereta	396/ 9	$5A3B1E_{87}1Oz_{182} + P_{96}$ II st. $10E_{77}+Ba_{71}$	Myrtilloso-polytrichosa Oxalidosa
3	Zemgale	Biksti	15/ 7, 9	$5P3B2E_{84}$ $6P3E1Oz_{134}$	Hylocomiosa Oxalidosa
4	Limbaži	Katvari	266/ 2	$5E_{105}2E_{125}2A_{95}1Oz_{145} + Os_{92}$	Oxalidosa
5	Sēlija	Jēkabpils	13/ 17	$4A4B2E_{97}+ A_{91}$ $10E$ IIst.$_{76}+$ Oz $_{200}$	Aegopodiosa
6	Ziemeļ kurzeme	Aizupe	208/ 15	$5B2A1Oz1E_{48}$ $1E_{68}+ Oz_{228}$ Bl_{43}	Oxalidosa
7	Ziemeļ kurzeme	Andumi	334/ 5, 6, 8	$7B1A1E1Oz_{77}$ $10E + Oz_{102}$ $7B2Oz1E_{87}+A_{82}+ Oz_{157}$	Hylocomiosa Oxalidosa
8	Ziemeļ vidzeme	Strenči	507/ 15, 16	$9P1E_{188}+Oz_{182}$ IIst. $8E_{98}2E_{52}$, $4Oz2P1E_{148}$ $2A1B_{78}$ $+E_{162}$ II st.	Myrtilloso-sphagnosa Myrtilloso-polytrichosa
9	Kuldīga	Rudbārži	317/ 14	$5E1P2B_{68}$ $1E1P_{83}$ $+B_{77}+Oz_{167}$	Hylocomiosa Oxalidosa

at two heights – 0.5 m and 1.5 m above the root collar. A uniform methodology for collecting and preparing the data for further processing has been used – to characterize a tree stand, sample stands of 500 m^2 were made around sample trees, in which the diameters of the trees of the 1st and 2nd floor were measured at breast height (DBH), also the total basal area G_{tot}, as well as G for separate species (Donis et al., 2004; Straupe, Donis, 2006). The conspectus of lichens in Latvia is used for the classification of lichen species (Piterāns, 2001). The mutual comparison of objects has been done by using Mann – Whitney and Kruskal – Wallis tests (Paura, Arhipova, 2002; Arhipova, Bāliņa, 2003). To determine and analyze the exposition of lichen species depending on the cardinal points the computer programme AXIS 1.1. (PISCES Conservation Ltd.) has been used (Fisher, 1993; Straupe, Donis, 2006). In all the research sites, using lichen species on tree trunks, the ecological evaluation has been performed, using the following seven indicators: light, temperature, continentality, moisture, reaction, amount of nutrients and toxicotolerance (Wirth, 1992).

Results and Discussion

The analysis of lichens and its percentile coverage in oak woodland key habitats.

28 lichen species, belonging to 23 genera were found on oak trees in the research sites (Piterāns, 2001) (Table 2). The epiphyte lichens stated in the research sites are morphologically divided in the following way: crustose lichens – 21, foliose lichens - 4 and fruticose lichens – 3 species. Five indicator species and three habitat specialist species of woodland key habitats, as well as five specially protected species, have been found on oaks. From the five especially protected species three species need to have microreserves (Ek et al., 2002; Bojāre et al., 2006). Indicator species and habitat specialist species of woodland key habitats have been found on 8 sites: the biggest number: 5 species (3 IS and 2 SBS) – on site 6, 4 species (3 IS un 1 SBS) – on site 7, and in the remaining sites – 1 to 3 species. WKH IS and SBS have not been found only on one - site 1.

The number of lichen species in objects in total and on the trunk at the different heights is shown in Table 3. The biggest number of species in total (11 species) has been found on two research sites: 1 and 2. The smallest number of species in total is on site 3 (4 species), in the remaining sites 7 – 8 species have been found. On all the sites the crustose lichen species *Lepraria incana* (L.) Ach. is present, constituting a significant proportion of coverage in percentage at the both heights 0.5 m and 1.5 m – correspondingly on average 28% and 39%, and 11 species are rarely found - only on one site. Only 4 species have been found at a certain height on the oak tree: *Peltigera praetextata* (Florke ex Sommerf.) Zopf, *Sclerophora amabilis* (Tibell) Tibell, *Arthothelium ruanum* A. Massal. Körb. – at the height of 0.5 m and *Dimerella pineti* (Ach.) Vezda – at the height of 1.5 m. Most species at heights of 0.5 m and 1.5 m have been found on the site 1 (at each height 10 species), the smallest number of species at the height of 0.5 m – on site 7 (3 species), but 1.5 m – on site 3 (3 species). On most sites (6 sites) the greatest diversity of species was found on the trunk at the height of 1.5 m, but on 2 sites - the number of species is identical at both heights (Table 3). The proportion of lichens of different morphological groups at different heights on trunks is similar: 19 crustose and 3 fruticose lichen species (at both heights), but foliose lichen correspondingly - 4 and 3 species. The composition of lichens on the trunk is more homogenuous than on the base of the trunk (Sõmermaa, 1972), but it could differ on old trees because with the age the physical properties of the bark (water absorbtion capacity and texture) become more similar (Sõmermaa, 1972; Uliczka, Angelstam, 1999; Lõhmus, 2005).

Using the Mann – Whitney test it has been stated that the coverage in percentage of lichens differs significantly according to the height (p-value $= 0 < \alpha = 0.05$). The average coverage in percentage of lichens at the height of 0.5 m is 36%, but at 1.5 m – 52%. The biggest coverage is usually typical for the lower part of the tree trunk (Sõmermaa, 1972), but in the case of oak trees it can be attributed to the presence of moss on the base of the trunk and to mechanical damages of the bark (fallen off bark, cracks) which reduce the possible coverage with lichen. Using the Kruskal – Wallis test it has been stated that there are substantial differences among the research sites with regard to the coverage in percentage of lichens at the height of 1.5 m (p-value $= 0.084 < \alpha = 0.1$). The smallest coverage in percentage is on site 9 (37%), but the biggest – on site 8 (67%). Supposedly, the differences in lichens coverage in percentage at the height of 1.5 m on certain sites can be attributed to the local differences of these research sites.

Description and analysis of the dependence of lichen exposition on the cardinal points.

The vertical exposition of lichen on cardinal points is determined by the ecological situation (light, moisture) and physical-chemical properties

Table 2

The lichen species found in oak woodland key habitats

No.	Lichen species	Abbreviations used in data analysis	Morphological group	Status IS, SBS, SPS * MIK **
1	*Acrocordia gemmata* (Ach.) A. Massal.	Acge	K	IS
2	*Arthonia byssacea* (Weigel) Almq.	Arby	K	SBS, **
3	*Arthonia spadicea* Leight.	Arsp	K	IS, *
4	*Arthonia vinosa* Leight.	Arvi	K	IS, *
5	*Arthothelium ruanum* A. Massal. Körb.	Arru	K	-
6	*Buellia punctata* (Hoffm.) A. Massal.	Bupu	K	-
7	*Chaenotheca phaeocephala* (Turner) Th. Fr	Chph	K	SBS, **
8	*Chrysothrix candelaris* (L.) J. R. Laundon	Chca	K	-
9	*Cladonia coniocraea* (Flörke) Spreng.	Clco	Kr	-
10	*Dimerella pineti* (Ach.) Vezda	Dipi	K	-
11	*Evernia prunastri* (L.) Ach.	Evpr	Kr	-
12	*Graphis scripta* (L.) Ach.	Grsc	K	IS
13	*Hypogymnia physodes* (L.) Nyl.	Hyp	L	-
14	*Lecanactis abietina* (Ach.) Körb.	Leab	K	IS
15	*Lecanora carpinea* (L.) Vain.	Leca	K	-
16	*Lecidella euphorea* (Flörke) Hertel.	Leeu	K	-
17	*Lepraria incana* (L.) Ach.	Lepr	K	-
18	*Melanelia glabratula* (Lamy) Essl.	Megl	L	-
19	*Opegrapha varia* Pers.	Opva	K	-
20	*Parmelia sulcata* Taylor	Parm	L	-
21	*Peltigera praetextata* (Florke ex Sommerf.) Zopf	Pepr	L	-
22	*Pertusaria albescens* (Huds.) M. Choisy & Werner	Peal	K	-
23	*Pertusaria amara* (Ach.) Nyl.	Peam	K	-
24	*Pertusaria coccodes* (Ach.) Nyl.	Peco	K	-
25	*Pertusaria flavida* (DC.) J. R. Laundon	Pefl	K	-
26	*Phlyctis argena* (Spreng.) Flot	Phar	K	-
27	*Ramalina farinacea* (L.) Ach.	Rafa	Kr	-
28	*Sclerophora amabilis* (Tibell) Tibell	Scle	K	SBS, **

Designations: K – crustose, L - foliose, Kr – fruticose lichens; SPS – especially protected species; MIK – especially protected species, for which microreserves should be created.

(the age of the tree, the texture of the bark surface and the presence of nutrients) (Sõmermaa, 1972; Znotiņa, 2003). The number and the exposition of lichen species depending on the cardinal points on the trunk at the height of 0.5 m and 1.5 m on the research sites are shown in Table 3.

At the height of 0.5 m more species can be found on the S and SE side (in 6 sites), but at the height of 1.5 m - on the N and NW side (in 7 sites). At the base better moisture conditions are provided for lichens in addition, at the height of 0.5 m most trees had mosses which compete with lichens for a definite place and moisture, which could be an additional factor explaining the location of lichens on the S and SE side. Higher up on the trunk the lighting is better, but the amount of moisture decreases. Therefore, most species occupy N and NW side. There are data available that the specifics of substratum correspond to definite ecological conditions. Thus, approximately in 60% of cases the lichen community is determined by the substratum factor and in 40% of cases by microclimate (Sõmermaa, 1972; Uliczka, Angelstam, 1999; Lõhmus, 2005).

The mean values of expositions of lichen species depending on the cardinal points are shown in Fig. 2. WKH indicator species

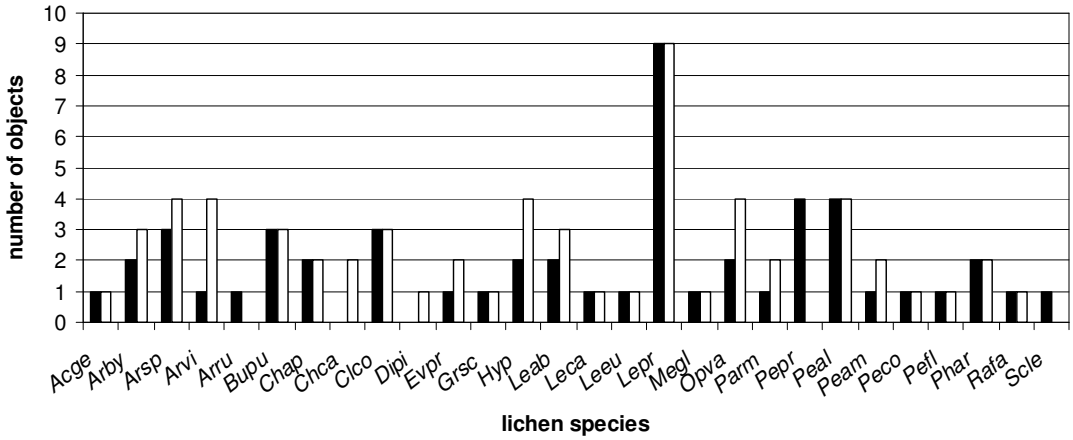

Figure 1. The occurrence of lichen species at the height of 0.5 m and 1.5 m on the research sites (□ – 0.5 m, ■ – 1.5 m).

Abbreviations: in Table 2.

Arthonia spadicea Leight., *Arthonia vinosa* Leight., *Lecanactis abietina* and a habitat specialist species *Arthonia byssacea* (Weigel) Almq. that occur on several sites have been analysed. IS *Arthonia spadicea* on oak trees is found at both heights (on the site 7 only at the height of 1.5 m), the mean value at the height of 0.5 is on the SW side, but at the height of 1.5 m - on the NW side. IS *Arthonia vinosa* on the oak trees is found mainly at the height of 1.5 m (on site 9 at both heights). On different sites it occupies different exposition niches depending on the cardinal points, but the mean value at the height of 0.5 m is on the S side, but at the height of 1.5 m – on the E side. IS *Lecanactis abietina*, which usually occurs on spruces and indicates high content of moisture and long-lasting tree continuity is mostly found at both heights (on the site 7 only at the height of 1.5 m). The mean value at the height of 0.5 m is on the SE side, but at the height of 1.5 m – on the S side. SBS *Arthonia byssacea* on different sites and at different heights occupy different exposition niches depending on the cardinal points. On the site 7 it is found only at the height of 1.5 m, but on the sites with a smaller basal area – also at the height of 0.5 m, respectively the mean value at the height of 0.5 m is on the E side, but at 1.5 m – on the SW side.

The description of lichen ecological indicators.

The description of stand basal area and lichen ecological indicators on research sites is shown in Table 4. The evaluation of research sites is

Table 3

The number and the exposition of lichen species depending on the cardinal points on the trunk at the height of 0.5 m and 1.5 m on the research sites

Site code	Number of species						
	In Total	Height 0.5 m			Height 1.5 m		
		In total	Z, ZR	D, DA	In total	Z, ZR	D, DA
1	11	10	2	8	10	4	6
2	11	7	0	7	9	5	4
3	4	4	2	2	3	3	0
4	8	6	1	5	7	3	4
5	8	5	2	3	6	4	2
6	8	7	1	6	8	5	3
7	7	3	1	2	7	5	2
8	8	5	3	2	5	3	2
9	8	5	3	2	7	4	3

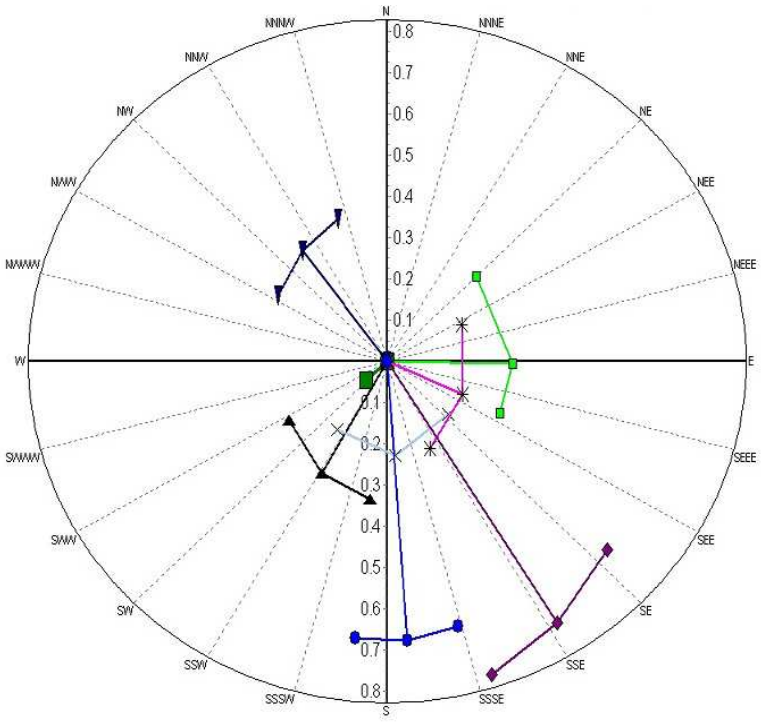

Fig. 2. The mean values of expositions of lichen species depending on the cardinal points at the height 0.5 and 1.5.

Designations: - OZ05Arby, - OZ15Arby, -Oz05Arsp, - Oz15Arsp, - Oz05Arvi, - Oz15Arvi, - Oz05Leab, - Oz15Leab.

Figure 2. The mean values of expositions of lichen species depending on the cardinal points at the height 0.5 and 1.5.

Abbreviations of lichen species used in data analysis in Table 2.

Table 4

The description of a stand basal area and lichen ecological indicators in research sites

Indicators	Site codes								
	1	2	3	4	5	6	7	8	9
Basal area G (m^2 ha^{-1})	26.90	35.10	40.90	44.30	44.90	47.90	47.00	48.00	37.90
Light	5.91	5.10	5.00	5.50	4.14	3.63	3.57	4.29	4.13
Temperature	5.00	5.00	5.25	5.33	5.67	5.38	5.43	5.33	5.33
Continentality	5.82	4.80	4.75	4.90	4.71	3.50	3.86	4.57	4.75
Moisture	3.20	3.89	4.25	3.75	4.17	4.38	4.57	4.17	4.00
pH	4.27	3.60	5.00	4.50	4.29	3.38	3.71	4.00	3.63
The nutrients	3.18	2.80	3.75	3.13	2.71	2.50	2.86	2.71	2.50
Toksicotolerance	6.70	6.38	5.00	5.71	5.20	4.86	6.00	5.40	5.86

done in accordance with lichen communities and the means of values of lichen ecological indicators (Wirth, 1992).

According to the results the stand basal area correlates with the following ecological indicators: light, temperature and moisture, but the interconnection among continentality, reaction, amount of nutrients and toxicotolerance

is not found. In sample plots with higher stand basal area more shade-tolerant lichen species (relative lighting 5 – 10 %) and higher moisture are found. Using the values of the indicator continentality it is possible to divide research sites into 2 groups: the group which is located in SW, S, SE part of Latvia (higher means of values of continentality) and the group which is located in NW, NE part of Latvia (lower means of values of continentality; site 6 and 7 is affected by the near location of the Baltic sea, but site 8 – by location on the banks of Gauja). There is no explanation for high mean of values of continentality of site 4. The reaction of substratum–bark is rather acid on all the sites (pH 4.1 – 4.8) and there is a medium amount of minerals on the bark which is characteristic of the bark of oaks. The highest value of the reaction of substratum–bark (pH 4.9 – 5.6) and bigger amount of nutrients are on site 3; it could be explained by the site location near Jaunakmene cement plant in Lithuania and influence of its emissions. The pH value of oak giant trees is not different because with the age the physical properties of the bark become more similar. The values of indicator of toxicotolerance show the sensitivity of lichen species to air pollution (Wirth, 1992). The highest total value of toxicotolerance is established on site 1, which depends on site location at the edge of the forest by the roadside and the community of lichen species without rare species and WKH's IS and SBS. The lowest value of toxicotolerance is established on site 6, where the biggest number of WKH's IS and SBS is found (in total 5 species).

Conclusions

1. On oak trees in the research sites 28 lichen species, belonging to 23 genera were found. Five indicator species and three habitat specialist species of woodland key habitats, as well as five especially protected species have been found on oaks. The largest number of species in total – 11 species have been found on two research sites: 1 and 2. The fewest number of species in total is on site 3 (four species), on the remaining sites seven – eight species have been found. On all the sites the crustose lichen species *Lepraria incana* (L.) Ach. is present.
2. The diversity of lichen species and the lichen cover in percentage is smaller at the trunk height of 0.5 m than at the trunk height of 1.5 m; it can be attributed to the physical properties of the bark which are similar with respect of age, the presence of moss on the base of the trunk and to mechanical damages of the bark (fallen off bark, cracks). There are substantial differences among the research sites with regard to the coverage in percentage of lichens at the height of 1.5 m (the smallest coverage in percentage is on site 9 – 37%, but the biggest – on site 8 – 67%). Supposedly, the diferences in lichens coverage in percentage at the height of 1.5 m on certain sites can be attributed to the local differences of these research sites.
3. At the height of 0.5 m more species can be found on S and SE side, but at the height of 1.5 m on N and NW side, and this can be attributed to differences of moisture at different heights, as well as the competition between lichens and mosses on the base of the trunk.
4. The stand basal area of oak woodland key habitats correlates with following ecological indicators: light, temperature and moisture, but interconnection among continentality, reaction, amount of nutrients and toxicotolerance is not found. The highest value of toxicotolerance is established on site 1, which depends on site location on the edge of forest near the road and the community of lichen species without rare, WKH's IS and SBS. The lowest value of toxicotolerance is established on site 6, where the biggest number of WKH's IS and SBS is found (in total 5 species).

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