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FENNOSCANDIAN WOODED MEADOWS 6530* MANAGEMENT EFFECTIVENESS EVALUATION USING SCORES OF EPIPHYTIC LICHEN FLORA

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The research was implemented in 6530* EU protected habitat. The main objects of the research are epiphytic lichens that grow on common oak *Quercus robur*. Totally lichens were collected from five different areas and final amount of plots is 20. Data about four ecological factors in habitat was collected. All collected data was processed by PC-ORD5.DCA (Decorana) analysis, and the ordination of species was made. The indicator species were defined for 6530* habitat excellent long-term management condition.

Key words: Epiphytic lichens, *Quercus robur*, management, 6530* Fennoscandian wooded meadows, indicator species, ordination.

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INTRODUCTION

About 570 lichen species have been recorded in Latvia (Piterāns 2001). Researchers often use a single species of lichen as indicators of natural habitat condition.(Lārmanis 2000) Unfortunately, at the moment, distribution and species composition of this group of organisms is very little studied in the territory of Latvia.

In 2010 the LIFE programme project „Eremita Meadows" has begun. As a part of the project it is planned to make management activities of the European Union 6530* protected habitat - fennoscandian wooded meadows. The description of habitat is the same in all EU countries, but in nature habitats differ. In different countries predominant tree species and type of management differs. There are intensive activities carried out in neighbouring countries (Marmor 2011). Wooded meadows were widespread in the past around the Baltic Sea (Hæggstrom 1995). In Latvia this habitat is not well studied at the present moment.

In Latvian interpretation, one of the main habitat -forming components are simple oaks (*Quercus robur*), which are growing in the meadows (Auniņš 2010). It was found that many rare epiphytic lichen species are using common oak as a substrate (Prigodina 2009). In earlier studies by T. Ranius it is found that some rare crustose lichen species commonly chooses old oaks as a substrate (Ranius 2008).

It is planned to clear the overgrown areas around oaks and to continue appropriate management of the territory in the future. The main purpose of the management is to provide support for biological diversity in the habitat. By the word "management" is meant a set of measures,

which are planned to perform - to cut the bushes and trees growing around the tree crown to achieve a greater illumination of a tree trunk, and grazing grass in the meadows. In recent years, Europe has carried out a number of similar projects (Paltto H. 2008). Parallel studies were conducted demonstrating a beneficial effect on the management of epiphytic lichen colonies in Sweden and Estonia (Johanson 2011).

The main object of the study is epiphytic lichens that colonize oak (*Quercus robur*) in 6530* habitat.

Central task of the research is to understand and identify correlations between epiphytic lichen species, which grow in 6530* habitat, environmental variability and constant ecological factors. There are 4 ecological factors taken into account, such as distance to the sea, management around the tree crown, the average annual rainfall. The decision of measuring the tree age is based on G. Thor research where the correlation between tree diameter and red-listed lichen species was proved. (Thor 2010).

In the study there are presented lichens that are known from 20 plots out of 5 different localities in Latvia. In each plot ecological factors were measured and considered. After obtaining data they were computed to get the average count of species from all plots, frequency of species occurrence in all plots, the observed average number of species in different habitat management stages.

MATERIAL AND METHODS

Field work was carried out from autumn 2010 till spring 2013. Each plot was surveyed at least twice. The research was done in „Eglone" - 4 plots, „Raķupe Valley" natural reserves – 6 plots, „Dviete wetlands"- 3 plots, „Embūte" natural parks - 2 plots, Ziemeļgauja protected landscape area – 5 plots (Fig. 1)

The studied territories were chosen at random. Five fennoscandian wooded meadows habitat territories in different parts of the Republic of Latvia were surveyed.

Plots were pointed with GPS coordinates LKS-92 system. Positioning accuracy is ± 2 meters. The data from the GPS equipment was exported to a PC, where it was further processed with ESRI

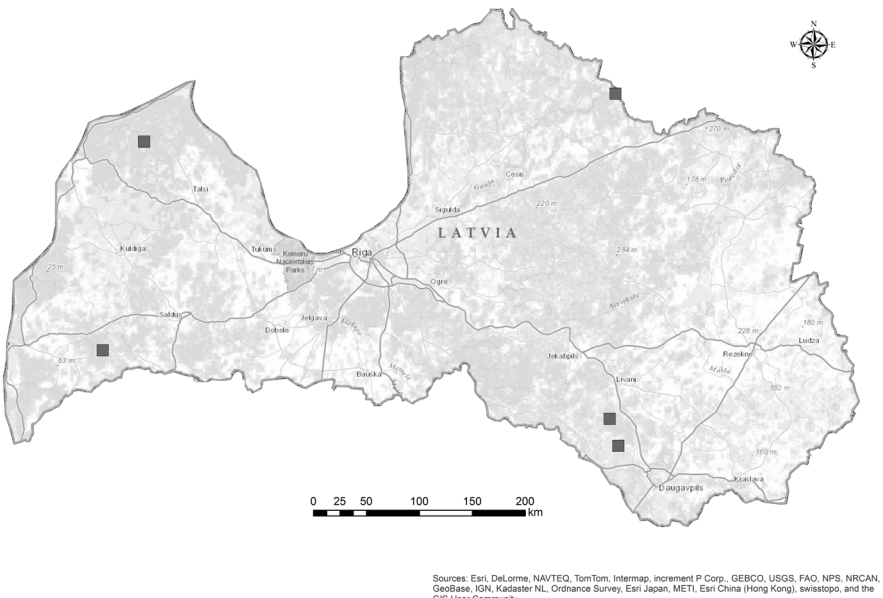

Fig. 1. 6530* habitat teritories wich were surveyd.

Table 1. LKS coordinates of plots

Name of plots	X Coordinates of plots	Y Coordinates of plots
Ziemeļgauja protected landscape area I	629315	6396753
Ziemeļgauja protected landscape area II	629416	6396748
Ziemeļgauja protected landscape area III	629490	6396695
Nature reserve „Raķupes ieleja" IV	390349	6372126
Nature reserve „Raķupes ieleja" V	390209	6371786
Nature reserve „Raķupes ieleja" VI	390358	6372090
Nature reserve „Raķupes ieleja" VII	390205	6371792
Nature reserve „Raķupes ieleja" VIII	390334	6371970
Nature reserve „Raķupes ieleja" IX	390339	6372035
Nature park „Embūte" X	365765	6265254
Nature park „Embūte"XI	365762	6265262
Nature park „Dviete paliene" XII	636910	6216030
Nature park „Dviete paliene" XIII	636837	6215967
Nature park „Dviete paliene" XIV	636740	6216037
Nature reserve „Eglone" XV	631081	6228490
Nature reserve „Eglone" XVI	631010	6228440
Ziemeļgauja protected landscape area XVII	629310	6396615
Ziemeļgauja protected landscape area XVIII	629374	6396679
Nature reserve „Eglone" XIX	631518	6229266
Nature reserve „Eglone" XX	631496	6229254

ArcGIS 10 software.

Names and coordinates of plots are presented in Table 1.

Measurement of ecological factors

List of factors:

1) Tree age
2) Management around the tree crown
3) Distance to the sea
4) The average annual rainfall.

In view of the Thor and Johansson's research findings, a decision was made to estimate the size of tree. (Thor & Johansson 2011). Tree size is valued in scale from 1 to 3:

1 -trees that are not older than 120 years;
2- tree age is about 120-200 years;
3- trees that are older than 200 years.

Most 6530* habitats in Latvia are currently abandoned. It is related to the changes in land use. The main goal of management is to recover wooded meadows to the state in which they were many years ago.

Management is valued in scale from 1 to 5

1-management has not been done for at least 20 years, and there are other trees growing around the plot tree and they are as high as the plot tree. (I)

2-management has not been done for at least 20 years, and there are other trees growing around the plot tree, but they are not higher than the plot tree. (II)

3-management has not been done for at least 10 years, and there are bushes growing around the tree. (III)

4-management has not been done for at least 5 years, and there is no natural grassland around the tree, and level of shadow from the other trees is minimal. (IV)

5-management was regular, there is a natural meadow around the tree. (V)

Data about distance to the sea and the average annual rainfall is taken from Latvian Geographical Atlas.

Data about epiphytic lichen species was collected from a tree bark at a height 0,3m – 1,80m from the bottom of the tree.

The frequency of detection for all species was rated in scale from 1 to 3:
1 – species are found in small number only in one part of the plot;
2 – species is common within the plot;
3 – species are dominant within this plot.

Collected data were processed in Excel table, and applied in PC-ORD5 (McCune & Mefford 1999). It was decided to use DCA (Decorana) analyse packet. After obtaining statistics-correlation is considered significant if r <0.05, correlation is regarded as especially significant if r <0.01.(Liepa 1974). Program was used allowing to display the ordination of significant factors and lichen species.

RESULTS

The research has been carried out from autumn 2011 till spring 2013. In total 20 plots were surveyed in 5 different places. There have been detected 31 epiphytic lichen species, 5 are protected by directive of Cabinet of Ministers of the Republic of Latvia. See Table 2.

Most commonly found species were: *Evernia prunastri, Hypogymnia physodes, Lepraria incana, Pertusaria amara, Pertusaria albescens, Ramalina farinacea.*

Rarely founded species were: *Acrocordia gemmata* (Ach.) Massal., ***Arthonia byssacea*** (Weigel) Almq., ***Arthonia vinosa*** Zahlbr., ***Calicium adspersum*** Pers., *Calicium viride* Pers., *Chaenotheca furfuracea* (L.) Tibell., *Chaenotheca stemonea* (Ach.) Müll.Arg., *Graphis scripta* (L.) Ach., ***Pertusaria flavida*** (DC.) J.R. Laundon., *Physconia distorta* (With.) J. R. Laundon., *Ramalina fraxinea* (L.) Ach., ***Sclerophora amabilis*** (Tibell) Tibell., *Cladonia pyxidata* (L.) Hoffm.

The observed average number of species in different habitat management stages. (Fig. 2.).

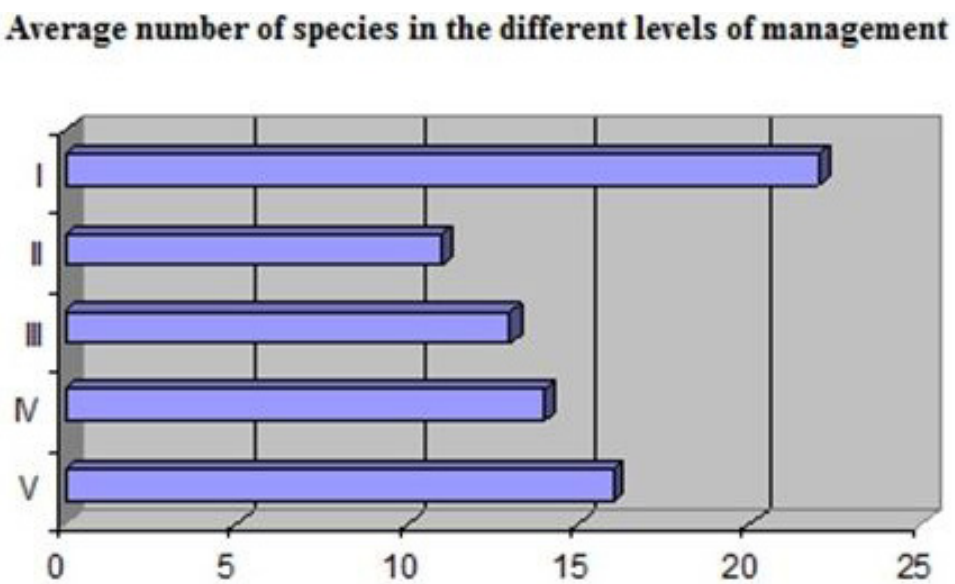

Fig 2. The observed average number of species in different habitat management stages.

Table 2. Detected species and frequency of detecting

Species/Plots	Reducted title of species	Frequency																			
		I	**II**	**III**	**IV**	**V**	**VI**	**VII**	**VIII**	**IX**	**X**	**XI**	**XII**	**XIII**	**XIV**	**XV**	**XVI**	**XVII**	**XVIII**	**XIX**	**XX**
Acrocordia gemmata (Ach.) Massal. 1854	*Acr.gem.*	1																		2	2
Arthonia byssacea (Weigel) Almq. 1880	*Art.bys.*																			3	3
Arthonia vinosa Zahlbr. (1922)	*Art.vin.*																			2	3
Calicium adspersum Pers. 1798	*Clc.ads.*	2		2					1	2											
Calicium viride Pers. 1794	*Clc.vrd.*	1		1												1	2				
Chaenotheca brunneola (Ach.) Müll.Arg. 1862	*Chn.brn.*	2	2		1			2	1		2			1		2		2		1	1
Chaenotheca furfuracea (L.) Tibell. 1984	*Chn.frf.*	1		2												3	2		1		
Chaenotheca stemonea (Ach.) Müll.Arg. 1862	*Chn.stm.*	2		2	1				2									1			
Evernia prunastri (L.) Ach. 1810	*Evr.prn.*	2	2	1	2	3	3	3	2	2	2	2	1	2	2	3	1	2	1	1	1
Graphis scripta (L.) Ach. 1809	*Gra.scr.*																			1	
Hypocenomyce scalaris (Ach. ex Lilj.) M. Choisy. 1951	*Hpc.scl.*	1		2	2			2	1	2			2								
Hypogymnia physodes (L.) Nyl. 1896	*Hyp.phy.*	1	1	1	2	2	1	2	1	1	2	2	1	1	2	1	2		1		1
Lecanora allophana (Ach.) NyL .1888	*Lcn.all.*	2	1															2	1	1	

Species/Plots	Reducted title of species	Frequency																			
		I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV	XV	XVI	XVII	XVIII	XIX	XX
Lecanora carpinea (L.) Vainio 1888	*Lcn.crp.*	2		1			2						2	1			2	2	1	1	
Lepraria incana (L.) Ach. 1803	*Lpr.inc.*	1	2	2	2	1	2	2	1	1	2	1	2	2	2	1	1	2	2	2	1
Melanelia olivacea (L.) Essl. (1978	*Mln.olv.*	2	2		1	2		2					1	1	2	2			2		
Opegrapha rufescens Pers. 1794	*Oph.ruf*																		1	2	1
Opegrapha vulgaris Humb. 1793	*Oph.vul.*																		1	1	1
Parmelia sulcata Taylor. 1836	*Prm.slc.*	2	2	1	2	2	3	3	2	2	2	3	3	2	1	2	2	1	1	1	1
Pertusaria albescens (Hudson) Choisy & Werner. 1932	*Prt.alb.*	2		1		2		2	2	1	1	1	1	1		1	1		1		
Pertusaria amara (Ach.) Nyl. 1873	*Prt.ama.*	2	1	2	2	1	1	1	1	2		2	2	1	1		1	2	2	1	
Pertusaria flavida (DC.) J.R. Laundon. 1963	*Prt.flv.*	1																		2	
Phlyctis argena (Sprengel) Flotow.1850	*Plc.arg.*	2							2	2						2			2	2	
Physcia tenella (Scop.) DC. 1805	*Phy.tnl.*	1		2	2	2	2		2	1	1		2	2	2	2		1	1	1	2
Physconia distorta (With.) J. R. Laundon. 1984	*Phc.dst.*	2							1					1		1		2			
Ramalina farinacea (L.) Ach. 1810	*Rml.far.*	2	1	1	2	2	3	2	2	2	2	1		2	2	2	1	2	1	1	1
Ramalina fraxinea (L.) Ach. 1814.	*Rml.fra.*																	1		2	1

Species/Plots	Reduced title of species	Frequency																			
		I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV	XV	XVI	XVII	XVIII	XIX	XX
Xanthoria parietina (L.) Th. Fr. 1860	*Xnt.prt.*	1	1							2							1				
Sclerophora amabilis (Tibell) Tibell. 1984	*Scl.ama.*																	1		1	1
Cladonia coniocraea (Flörke) Sprengel. 1827	*Cld.con.*	1	1	2	2	1	2	2	1	1	1	2	2			1	2	2	1	2	2
Cladonia pyxidata (L.) Hoffm. (1796)	*Cld.pyx.*	1						2											1		1

The biggest average number of species was detected in afforested habitats and regularly managed habitats. The lowest number of species was detected in habitats which were not managed over a time period of 5 - 20 years.

The data of the plot average rainfall, management, tree size and distance from the sea is processed in statistical data analysis in PC-ORD 5.0. (DCA) DCA Eigenvalue of first axis λ= 0,332 , Eigenvalue of second axis λ= 0,136, eigenvalue of third axis λ= 0,055.

Correlation is considered significant if $r < 0.05$, correlation is considered as especially significant if $r < 0.01$ (Liepa 1974). Environmental factors are correlated with the first axis is relevant only to management. The correlation is negative, management intensity increases towards the axis. More intensive management of the enterprise from the left to the right relative to the first axis (Axis 1). Environmental factors are not significant correlation with the second axis. At the same time, such environmental factors as tree age are essential for to the third axis (Axis 3). The correlation is positive, and the tree age increases from the bottom upwards relative to the third axis. Therefore this effect is made to examine species ordination between the first and the third axis. (Fig. 3.)

Fig. 3. Ordinations of plots between 1st (management) and 3rd (tree age) axis. Vertical vector is tree age, horizontal vector is management. Visually it is possible to allocate all lichen species in 4 ordination groups.

Group 1.: Species that are localized in the top of left ordination system corner. There is found a significant correlation between the first axis and species, but is not significant between the third axis and species. These species were commonly found in long-term managed areas. These species are *Calicium adspersum*, *Chaentheca stemonea*, *Hypcenmicea scalaris*. In case of *Xanthoria parietina* correlation was not significant.

Group 2.: Species that are localized in the top of right ordination system corner. There was found

an especially significant correlation between species and the first axis, and a significant correlation between the third axis. Species that are localized in this group were commonly found in long-term unmanaged old trees. These species are *Acrocordia gemmata*, *Cladonia pyxidata*, *Pertusaria flavida*.

Group 3.: Species that are localized in the right side of ordination system middle. There was found an especially significant positive correlation between the first axis and species. Species that are localized in this group were commonly found in long-term unmanaged trees. These species are *Arthonia vinosa*, *Arthonia bysacea*, *Ophegrapha vulgare*, *Ophegrapha rufescens*, *Sclerophora amabilis*, *Ramalina polynaria*, *Lecanora allophana*, *Chaenotheca bruneola*.

Group 4. : Species that are localized in the bottom left side of ordination system. There was not found a significantly negative correlation between axis and species. These species are *Chaenotheca furfuracea* and *Calicium viride*.

The other lichen species have no specific ecological requirement in this habitat. These species were found in different management conditions mostly on all age trees. These species

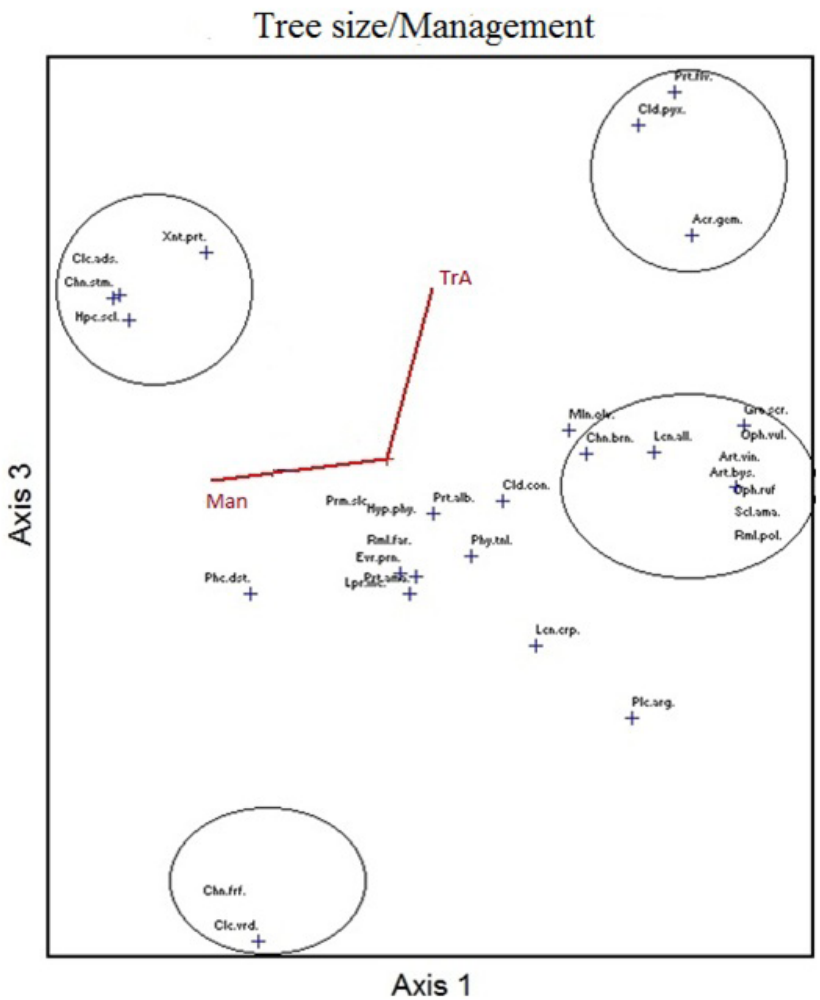

Fig. 3. Ordination of species with vectors.

are *Evernia prunastri, Melanelia olivacea, Pertusaria albescens, Ramalina farinacea, Hypogimnia physdes, Physcia tenella, Cladonia coneocrea,Pertusaria amara.*

DISCUSSION

Taking into account the fact that there was examined only one tree species (*Quercus robur*), and a relatively small number of plots was surveyed, it can be considered that epiphytic lichen species diversity is very high. For example, in Estonian coniferous forests only 30 epiphytic lichen species have been recorded on spruces and pines. (Marmor 2011).

It has been found that in long-term managed habitat the average epiphytic lichen species number is greater than the relatively less time managed habitats. At the same time, it is found that the amount of epiphytic lichens is growing rapidly in the oaks which are afforested. (Fig. 2.). It means that the amount of epiphytic lichen species is growing in long-term stable habitats. Before starting management activities it is important to know the condition of the habitat. Diversity and abundance of rare and protected species (in Latvia) is greater in habitats that were not managed for a long time, and a forest had developed around the tree canopy. Some lichen species were presented almost in all plots. These species do not need special ecological requirements in certain environmental conditions. *Calicium adspersum* can be used as indicator. Commonly this species habitat is old *Quercus* bark. (Smith 2011).This species indicates this habitat excellent long-term management condition.

CONCLUSIONS

In light of all collected data, it can be argued that the tree evaluation before management activities must be very thorough. Assessing the state of trees, in parallel there must be estimate of how great scourges will be done for epiphytic lichens if management activities shall be undertaken. If a tree that is planned for a management is afforested and there are growing epiphytic lichens that have such requirements, it is better to cancel activities. If there are no epiphytic lichens that have special ecological requirements, then implementation of planned activities for getting the greater amount of epiphytic lichens is possible.

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