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CHANGES OF THE ECOLOGICAL CONDITIONS IN THE BÁB FOREST ON THE BASIS OF A BIOINDICATION METHOD

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Abstract

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This work analyses the changes of ecological conditions in the Báb forest on the basis of a bioindication method. The comparison is made between the phytocenological records from the years 1968–1969 and 2013 where permanent research plots (PRPs) were established in the forest coppice and on clearcuts. In 2013, the amount of photophilous and thermophilic species increased mainly on the clearcut PRP and the amount of suboceanic taxa on PRP in the forest coppice. Moreover, there is also an increase of taxa like nitrogen-rich posts. On the other hand, the share of fresh soils indicators and acidophilous species significantly decreased. The change in the ratio of the econumbers of the observed ecofactors between the records from 1968–1969 and 2013 is caused mainly by a diversified management. It is the formation of clearcuts due to which synanthropic, clearcut and invasive species occupy the free space. The given species are mainly thermophilic, photophilous representatives and representatives of nitrogen-rich soils and they have a significant influence on the change in the percentual ratios of the econumbers of the six observed ecofactors.

Key words: eco-analysis, Ellenberg's indicator values, clearcuts, forest cover.

Introduction

Within the research of the climatic–anthropogenic impact on forest ecosystems, bioindication methods based on ecological demands of the particular plant species were used too often. This method was suggested by Ellenberg (1979, 1992) who defined the ecological demands for most of the plant species with relation to the six most important ecological factors: light, temperature, continentality, moisture, effect of pH and nitrogen (Vladovič et al., 2008). Jurko (1980, 1986) mentions advantages of the bioindication method, such as its simplicity, rapidity, quantifying, clarity and integration of long-term influences on the environment.

The study brings the results of the research of the ecological conditions change in the Báb forest within the period of 45 years on the basis of the bioindication method. Administratively, the Báb forest area belongs to cadastre of village Veľký Báb, district Nitra and to Nitra Region. It is situated on Nitra loess upland, 19 km from Nitra and 15 km from Sereď. Two reserve areas can be found here – National Nature Reserve Báb forest and the Protected Area Báb Park.

This forest is remnant of original native forest complexes. Its total area is 66 ha. In the past, it was marked by anthropogenic impacts especially short rotation management. Its surroundings were mainly turned into wide-area fields and vineyards (Kubíček, Brechtl, 1970). The Báb forest represents a climax stage of forest succession on loess (Eliáš, 2010). The forest community is included in the unit *Carpion betuli* (Mayer, 1937) and the association *Primulo veris-Carpinetum* (Neuhäusl, Neuhäuslová-Novotná, 1964).

From 1967 to 1974 there was conducted a synecology research under the International Biological Program (IBP) and the 'Man and Biosphere' (MaB) program. Slovakia was chosen, in a global network of study areas IBP, as a representative ecosystem of oak-hornbeam forest in the loess upland.

The research presented in this contribution overlies on the phytocenological analysis (phytocenological records) and resultant assignment of Ellenberg's ecovalues on each of the plant species. One part of the research in the 1960s was also a realisation of 13 phytocenological records in the Báb forest, namely in 1968–1969 (Kubíček, Brechtl, 1970). This research relies on the above mentioned records while comparing the ecological conditions.

Present phytocenological records were accomplished in the spring and summer period of 2013 on different habitats on clearcuts and in the forest vegetation. The research was realised on the forest areas no 307, 310, 311, 312 and 314 (labelling according to the forest management plan in 2004) (Fig. 1). On the areas no 311–312, four clearcuts raised due to a one-time clearcutting in November 2006. The forest area no 314 is integrated in the National nature reserve of the Báb forest that presents the most indigenous forest community of the Báb forest. The forest coppices, which are located nearby the clearcuts, were thinned due to shelter-wood logging in November 2006 (forest areas no 311 and 312).

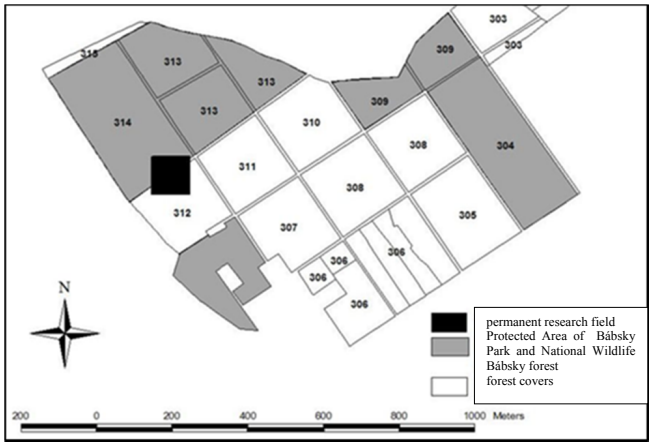

Fig. 1. The area of interest in the Báb forest (Source: ILE SAS, branch Nitra).

The aim of the given contribution is the evaluation of long-term changes of the environment by means of designating attributes of plants and the evaluation of plant species which take part in this change. The long-term changes of the environment are expressed in the

comparison of the econumber ratio (%) of the particular ecofactors counted from the phytocenological records from the years 1968–1969 and 2013. In the case of the comparison of the records '1968–1969' (hereinafter older records) and 2013 – clearcut, forest coppice (hereinafter new records) we can presume significant climatic–anthropogenic influences on the given forest ecosystem. A significant change is expected mainly in the case of comparing the older records with the records from the clearcut permanent plots.

Methodology

In the observed area of the Báb forest, there were 32 areas in the size of 20×20 m (Fig. 2) measured and permanently marked in May and June 2011. The permanent plots are established only in the plateau part of the Báb forest. The given permanent research plots (PRP) are divided into two groups.

Fig. 2. The area of interest Báb forest with marked permanent plots
(Source: ILE SAS, branch Nitra).

The first group is formed by 20 areas established in the forest coppice – PRP no 13, 14, 15, 19, 20, 21, 22, 23, 24, 28, 29, 30, 34, 35, 36, 37, 38, 39, 40 and 41. Nine PRP (no 13, 14, 15, 19, 20, 21, 22, 23 and 24) are situated in the National nature reserve of the Báb forest. These are anthropically little influenced forest communities which have more or less indigenous structure of the upper tree, shrub and herb layer. These permanent plots are organised in three transects where each of the transects includes three areas. The remaining 11 forest areas are situated in the forest coppice where logging is expected in the future. Each transect consists of three measured and permanently marked permanent research plots.

The second group is formed by 12 areas (no 1–12) established on the four clearcuts. On each of the clearcuts there are three areas placed in the line transect.

New phytocenological records were made in the spring and summer period of 2013. The entries were accomplished according to standard phytocenological methods (Moravec, 1994). The older records were used from the work (Kubíček, Brechtl, 1970). The 10-item ordinal scale by Zlatník used in the above mentioned work was transformed to a 9-item ordinal scale (Westhoff, Van der Maarel, 1978):

1 – 1 or 2 individuals,
2 – more individuals, abundance less than 1 %,
3 – abundance 1–5% small number of individuals,
4 – abundance 1–5%, many individuals,
5 – abundance 5–12.5%,
6 – abundance 12.5–25%,
7 – abundance 25–50%,
8 – abundance 50–75%,
9 – abundance more than 75%.

The new as well as older phytocenological records were afterwards inserted into the database Turboveg (Hennekens, Schaminee, 2001). In the database to each of the plant species in the phytocenological record designating numbers (econumbers) of the six ecological factors 'light, temperature, continentality, moisture, effect of pH and nitrogen' were assigned (Ellenberg, 1992). For each ecological factor, percentage ratios of the abundance of the designating numbers were counted, i.e. ratios of the total abundance of species with the same designating value. The change of the environmental conditions is expressed in differences, i.e. differences in the average values of ratios of the econumbers abundance in time t^2 and t^1.

Results

From the observed ecofactor 'light' while evaluating the older '1968–1969' phytocenological records the biggest percentage ratio is reached by the econumber 4 and 5 (Table 1). The given econumbers represent plants between shade and half shade and plants of half shade. In the older records, these species represent them: *Acer platanoides, Campanula trachelium, Carex pilosa, Carpinus betulus, Cerasus avium, Geum urbanum, Hedera helix, Lathyrus vernus, Melica nutans, Milium effusum, Mycelis muralis, Sanicula europaea, Scrophularia nodosa, Sorbus torminalis, Tilia platyphyllos, Viola mirabilis, V. reichenbachiana* (econumber 4), *Acer campestre, Alliaria petiolata, Bromus benekenii, Convallaria majalis, Euonymus verrucosus, Geranium robertianum, Chaerophyllum temulum, Lamium maculatum, Lathyrus niger, Lithospermum purpurocaeruleum, Melittis melissophyllum, Poa nemoralis, Pulmonaria officinalis, Robinia pseudoacacia, Ulmus minor, Viola odorata* (econumber 5).

T a b l e 1. Significance of changes in percentage coverage of Ellenberg indicator values (econumbers) for factor „light" (according to Ellenberg, 1992).

Ecofactor		Econumber	x	1	2	3	4	5	6	7	8	9
Light	1968/69	Coverage of econumber (%)	0.4	-	10.4	13	28.3	27.7	9	10.4	0.7	-
	2013-forest cover		0.1	-	10.5	11.3	24.9	24.9	17.2	11.1	-	-
	Difference coverage of econumber (%)		**-0.3**	**-**	**0.1**	**-1.7**	**-3.4**	**-2.8**	**8.2**	**0.7**	**-0.7**	**-**
Light	1968/69	Coverage of econumber (%)	0.4	-	10.4	13	28.3	27.7	9	10.4	0.7	-
	2013-clearcut		1.6	-	6.8	7.6	19	20	12.4	17.4	12.3	2.3
	Difference coverage of econumber (%)		**1.2**	**-**	**-3.6**	**-5.4**	**-9.3**	**-7.7**	**3.4**	**7**	**11.6**	**2.3**

On PRP in the forest vegetation and on the clearcuts in 2013 also dominate species of the econumbers 4 and 5. However, these econumbers show a smaller percentage ratio. It is because in the forest vegetation species *Campanula trachelium, Melica nutans, Mycelis muralis, Scrophularia nodosa, Tilia platyphyllos* (econumber 4), *Chaerophyllum temulum, Lathyrus niger, Lithospermum purpurocaeruleum, Melittis melissophyllum* (econumber 5) are absent.

Within the PRP on the clearcuts there absent the same as well as new species: *Campanula trachelium, Cerasus avium, Lathyrus vernus, Mycelis muralis, Sanicula europaea, Scrophularia nodosa, Tilia platyphyllos, Sorbus torminalis* (econumber 4) and *Melittis melissophyllum* (econumber 5).

Taxa that represent econumbers 2 and 3 (shade-demanding plants up to full shade plants) are in the older records *Galium odoratum, Mercurialis perennis, Polygonatum multiflorum* (econumber 2), *Anemone ranunculoides, Brachypodium sylvaticum, Dentaria bulbifera, Epipactis helleborine, Galeobdolon luteum, Melica uniflora* (econumber 3). Into the forest records '2013' within the econumber 2 the species *Carex sylvatica* was added and within the econumber 3 species *Dentaria bulbifera* and *Epipactis helleborine* were absent. In the records on the clearcut PRP also absent the given species, namely *Dentaria bulbifera* and *Epipactis helleborine*.

Within econumbers 6 (plants between half shade and half sun) and 7 (plants of half sun) were in the older records presented by taxa: *Ajuga reptans, Cornus mas, Crataegus laevigata, Euonymus europaeus, Fragaria moschata, Roegneria canina, Quercus cerris, Torilis japonica, Vicia pisiformis* (econumber 6), *Cruciata laevipes, Dactylis glomerata, Galium aparine, Heracleum sphondylium, Hypericum perforatum, Ligustrum vulgare, Quercus robur, Rhamnus catharticus, Viburnum lantana* (econumber 7). Percentage increase of the given econumbers 6 and 7 in 2013 caused in the forest PRP the addition of species: *Anthriscus cerefolium, Fallopia dumetorum, Roegneria canina, Veronica officinalis, Viburnum opulus, Viola hirta* (econumber 6), *Calamagrostis epigejos, Crataegus monogyna, Lonicera caprifolium, Prunus spinosa, Quercus pubescens, Securigera varia, Swida sanguinea,* (econumber 7).

A notable change is documented on the clearcuts were these species were added: *Astragalus glycyphyllos, Campanula rapunculoides, Echinochloa crus-galli, Fallopia dumetorum, Glechoma hederacea, Inula conyzae, Roegneria canina, Serratula tinctoria, Torilis japonica, Veronica chamaedrys, V. officinalis, Vicia tetrasperma, Viola hirta* (econumber 6), *Artemisia vulgaris, Aster lanceolatus, Capsella bursa-pastoris, Carex ovalis, Clematis vitalba, Clinopodium vulgare, Crataegus monogyna, Galium aparine, Humulus lupulus, Hypericum hirsutum, Chenopodium hybridum, Lamium purpureum, Lavatera thuringiaca, Prunus spinosa, Sambucus nigra, Securigera varia, Solanum dulcamara, Sonchus arvensis, Swida sanguinea, Taraxacum sect. Ruderalia* (econumber 7).

After the evaluation of the records '1968/69' to the econumber 8 (photophilous plants) belonged two species *Rosa canina* and *Tithymalus cyparissias*. In the forest records '2013' the given plants do not occur. On the clearcuts to the econumber 8 the following species were added: *Achillea millefolium, Ailanthus altissima, Ajuga genevensis, Amaranthus retroflexus, Arctium tomentosum, Ballota nigra, Cirsium arvense, Cirsium canum, Cirsium vulgare, Holosteum umbellatum, Linaria vulgaris, Sambucus ebulus, Silene latifolia ssp. alba, Tussilago farfara*.

Only on the clearcut the plants of full light were present (econumber 9): *Arctium lappa* and *Carduus acanthoides*. The plants of full shade (econumber 1) were not recorded neither in older nor in the new records. Moreover, a big change is not even recorded in the occurrence of indifferent species where in all records only the taxon *Urtica dioica* occurs.

The biggest percentage ratio within the ecofactor 'temperature' show the econumbers 5 and 6 both in the older as well as in the new records (clearcut and the forest vegetation) (Table 2). To the indicators of moderate heat (econumber 5) and indicators between moderate heat

and heat (econumber 6) in the older records '1968/1969' belong: *Brachypodium sylvaticum, Bromus benekenii, Cruciata laevipes, Cerasus avium, Dentaria bulbifera, Epipactis helleborine, Euonymus europaeus, Galeobdolon luteum, Galium odoratum, Geum urbanum, Hedera helix, Heracleum sphondylium, Melica uniflora, Rhamnus catharticus, Rosa canina, Sanicula europaea, Scrophularia nodosa, Viburnum lantana, Viola mirabilis* (econumber 5), *Acer campestre, A. platanoides, Alliaria petiolata, Anemone ranunculoides, Carex pilosa, Carpinus betulus, Crataegus laevigata, Euonymus verrucosus, Fragaria moschata, Galium aparine, Hypericum perforatum, Chaerophyllum temulum, Lathyrus niger, L. vernus, Ligustrum vulgare, Mycelis muralis, Pulmonaria officinalis, Quercus robur, Roegneria canina, Robinia pseudoacacia, Tilia platyphyllos, Torilis japonica, Viola odorata* (econumber 6).

T a b l e 2. Significance of changes in percentage coverage of Ellenberg indicator values (econumbers) for factor „temperature" (according to Ellenberg, 1992).

Ecofactor		Econumber	x	1	2	3	4	5	6	7	8	9
Temperature	1968/69	Coverage of econumber (%)	21.8	-	-	-	-	30.6	39.7	5.3	2.6	-
	2013-forest cover		11.4	-	-	-	-	26.4	47.7	9.4	5.2	-
	Difference coverage of econumber (%)		**-10.4**	-	-	-	-	**-4.2**	**8**	**4.1**	**2.6**	-
Temperature	1968/69	Coverage of econumber (%)	21.8	-	-	-	-	30.6	39.7	5.3	2.6	-
	2013-clearcut		18.3	-	-	-	-	28	46.6	2.3	4.7	-
	Difference coverage of econumber (%)		**-3.5**	-	-	-	-	**-2.6**	**6.9**	**-3**	**2.1**	-

On the PRP in the forest vegetation '2013' species of moderate heat (econumber 5) were absent, namely *Cruciata laevipes, Epipactis helleborine, Heracleum sphondylium, Rhamnus catharticus, Rosa canina, Scrophularia nodosa*. On the other hand, species between moderate heat and heat (econumber 6) were added: *Corydalis cava, C. solida, Fallopia dumetorum, Impatiens parviflora, Roegneria canina, Securigera varia, Vinca minor*. On the clearcuts the following taxa were absent *Cerasus avium, Cruciata laevipes, Epipactis helleborine, Heracleum sphondylium, Rhamnus catharticus, Sanicula europaea, Scrophularia nodosa* (econumber 5). On the other hand, many new species of the econumber 6 were added, namely *Arctium lappa, Artemisia vulgaris, Astragalus glycyphyllos, Ballota nigra, Campanula rapunculoides, Clematis vitalba, Corydalis cava, C. solida, Dactylis polygama, Fallopia dumetorum, Glechoma hederacea, Holosteum umbellatum, Humulus lupulus, Hypericum hirsutum, Chaerophyllum temulum, Chenopodium hybridum, Impatiens parviflora, Inula conyzae, Lavatera thuringiaca, Linaria vulgaris, Lonicera xylosteum, Roegneria canina, Sambucus ebulus, Securigera varia, Serratula tinctoria, Silene latifolia ssp. alba, Vicia angustifolia, V. tetrasperma, Vinca minor, Viola odorata*.

A significant percentage ratio was reached by indifferent species, in the older records these are presented by *Ajuga reptans, Campanula trachelium, Convallaria majalis, Dactylis glomerata, Geranium robertianum, Lamium maculatum, Melica nutans, Mercurialis perennis, Milium effusum, Poa nemoralis, Polygonatum multiflorum, Tithymalus cyparissias, Urtica dioica, Viola reichenbachiana*. To the indifferent species that were absent in the forest coppice

belong *Campanula trachelium, Melica nutans* and *Tithymalus cyparissias*. On PRP on the clearcuts also the same indifferent species was absent, namely *Campanula trachelium*.

In the percentage ratio further dominated species of heat (econumber 7) and species between heat and extreme heat (econumber 9). In older records the given econumbers were presented by the species *Cornus mas, Lithospermum purpurocaeruleum, Melittis melissophyllum, Sorbus torminalis, Ulmus minor, Vicia pisiformis* (econumber 7), *Quercus cerris* (econumber 8). In the forest coppice species *Anthriscus cerefolium* and *Lonicera caprifolium* (econumber 7), *Quercus pubescens* (econumber 8) were added. On PRP on the clearcut there was a decrease of econumber 7 species *Lithospermum purpurocaeruleum, Melittis melissophyllum, Sorbus torminalis* and on the other hand, a species of the econumber 8 *Ailanthus altissima* was added. In all phytocenological records the econumbers – 1, 2, 3, 4, are absent, which are the indicators of cold and econumber 9 as an indicator of extreme heat.

Within the ecofactor 'continentality' in all records percentage dominates the econumber 4 (suboceanic plants) and then follows the econumber 3 (taxa between suboceanic and oceanic species) (Table 3). Species of these econumbers in the older records '1968–1969' are: *Alliaria petiolata, Brachypodium sylvaticum, Campanula trachelium, Convallaria majalis, Dactylis glomerata, Epipactis helleborine, Euonymus europaeus, Galium aparine, Geranium robertianum, Chaerophyllum temulum, Ligustrum vulgare, Melica nutans, Mercurialis perennis, Milium effusum, Roegneria canina, Rosa canina, Sanicula europaea, Scrophularia nodosa, Torilis japonica, Viola odorata* (econumber 3), *Acer campestre, A. platanoides, Anemone ranunculoides, Bromus benekenii, Carpinus betulus, Cerasus avium, Cornus mas, Crataegus laevigata, Dentaria bulbifera, Fragaria moschata, Galeobdolon luteum, Lamium maculatum, Lathyrus niger, L. vernus, Lithospermum purpurocaeruleum, Quercus cerris, Robinia pseudoacacia, Sorbus torminalis, Tithymalus cyparissias, Vicia pisiformis, Viola mirabilis, V. reichenbachiana* (econumber 4).

T a b l e 3. Significance of changes in percentage coverage of Ellenberg indicator values (econumbers) for factor „continentality" (according to Ellenberg, 1992).

Ecofactor		Econumber	x	1	2	3	4	5	6	7	8	9
Continentality	1968/69	Coverage of econumber (%)	0.4	-	16.3	23	47	10.4	1.8	-	1	-
	2013-forest cover		0.1	-	13	19	52.5	11	2.7	0.1	1.8	-
	Difference coverage of econumber (%)		**-0.3**	-	**-3.3**	**-4**	**5.5**	**0.6**	**0.9**	**0.1**	**0.9**	-
Continentality	1968/69	Coverage of econumber (%)	0.4		16.3	23	47	10.4	1.8	-	1	-
	2013-clearcut		5.2	-	11.6	22.6	39.9	12.9	4.5	2.4	0.8	-
	Difference coverage of econumber (%)		**4.8**	-	**-4.7**	**-0.4**	**-7.1**	**2.5**	**2.7**	**2.4**	**-0.2**	-

In the forest coppice the species of the econumber 3 were absent, namely *Campanula trachelium, Epipactis helleborine, Chaerophyllum temulum, Melica nutans, Rosa canina, Roegneria canina, Scrophularia nodosa, Torilis japonica.* On the other hand, the species of the econumber 4 *Corydalis cava, Fallopia dumetorum, Gagea lutea, Lonicera caprifolium, Quercus*

pubescens and *Swida sanguinea* were added. On the clearcuts the same as well as new species were absent, such as *Campanula trachelium, Epipactis helleborine, Roegneria canina, Sanicula europaea, Scrophularia nodosa* (econumber 3), *Lathyrus niger, L. vernus, Sorbus torminalis, Vicia pisiformis* (econumber 4).

Widespread in the older records were also species of the econumber 2 (oceanic species): *Ajuga reptans, Galium odoratum, Hedera helix, Heracleum sphondylium, Melica uniflora, Melittis melissophyllum, Mycelis muralis, Tilia platyphyllos, Viburnum lantana.* These species decreased on PRP in the forest vegetation and they absent on the clearcuts '2013' as well: *Heracleum sphondylium, Melittis melissophyllum, Mycelis muralis, Tilia platyphyllos*.

The econumber 5 (intermediate species) in the older records represent plants *Carex pilosa, Cruciata laevipes, Geum urbanum, Hypericum perforatum, Poa nemoralis, Polygonatum multiflorum, Pulmonaria officinalis, Rhamnus catharticus, Ulmus minor.* During the forest records '2013' new species of the econumber 5 were recorded, such as *Corydalis solida, Impatiens parviflora, Prunus spinosa, Securigera varia, Viola hirta*. On the clearcuts also new species of this econumber were added, namely *Ballota nigra, Corydalis solida, Echinochloa crus-galli, Holosteum umbellatum, Impatiens parviflora, Linaria vulgaris, Prunus spinosa, Securigera varia, Serratula tinctoria, Vicia tetrasperma, Viola hirta.*

In the older records there also occur the species of the econumber 6 (subcontinental species) – *Quercus robur* and 8 (continental species) – *Euonymus verrucosus*. Into the forest records *Anthriscus cerefolium* was added and within the clearcut PRP the following species were added *Amaranthus retroflexus, Aster lanceolatus, Carduus acanthoides* and *Cirsium canum* (econumber 6). Within the econumber 8 the same taxa is present here, namely *Euonymus verrucosus*. In the older records there were not documented the taxa of the econumber 7 (plants between subcontinental and continental type). In the new records '2013' this econumber is presented in the forest coppice by the species *Calamagrostis epigejos* and on the clearcuts there are species *Arctium tomentosum* and *Chenopodium hybridum.*

Indifferent species were in the older entries '1968–1969' and in the forest coppice of '2013' presented only by the species *Urtica dioica* and on the clearcut PRP there occurred apart from the already mentioned taxon also new indifferent species, namely *Achillea millefolium, Ajuga genevensis, Artemisia vulgaris, Capsella bursa-pastoris, Cirsium arvense, Silene latifolia ssp. alba, Solanum dulcamara, Sonchus arvensis, Taraxacum sect. Ruderalia, Veronica chamaedrys.* Representants of the econumber 1 (euoceanic species) and of the econumber 9 (eucontinental species) did not occur.

From the observed ecofactor 'moisture' in all the records percentage dominate the econumber 5 which is the indicator of fresh soils (Table 4). In the older records of '1968/1969' this econumber is presented by species: *Acer campestre, Alliaria petiolata, Brachypodium sylvaticum, Bromus benekenii, Carex pilosa, Cerasus avium, Crataegus laevigata, Dactylis glomerata, Dentaria bulbifera, Epipactis helleborine, Euonymus europaeus, Fragaria moschata, Galeobdolon luteum, Galium odoratum, Geum urbanum, Hedera helix, Heracleum sphondylium, Chaerophyllum temulum, Lathyrus vernus, Melica uniflora, Milium effusum, Mycelis muralis, Poa nemoralis, Polygonatum multiflorum, Pulmonaria officinalis, Sanicula europaea, Torilis japonica, Viola mirabilis, V. odorata, V. reichenbachiana*. In the new entries of '2013' absence of the forest PRP species appears, such as *Epipactis helleborine, Fragaria moschata, Heracleum*

sphondylium, Chaerophyllum temulum, Mycelis muralis, Torilis japonica. On the clearcut PRP these species are not present *Cerasus avium, Epipactis helleborine, Heracleum sphondylium, Lathyrus vernus, Mycelis muralis, Sanicula europaea*.

T a b l e 4. Significance of changes in percentage coverage of Ellenberg indicator values (econumbers) for factor „moisture" (according to Ellenberg, 1992).

Ecofactor		Econumber	x	1	2	3	4	5	6	7	8	9
Moisture	1968/69	Coverage of econumber (%)	21.7	-	-	1	15	55.8	6.6	-	-	-
	2013-forest cover		22	-	-	1	21.2	48	8	-	-	-
	Difference coverage of econumber (%)		**0.3**	**-**	**-**	**0.1**	**6.2**	**-7.8**	**1.4**	**-**	**-**	**-**
Moisture	1968/69	Coverage of econumber (%)	21.7	-	-	1	15	55.8	6.6	-	-	-
	2013-clearcut		23.4	-	-	4	15.5	46	10.5	0.1	0.4	-
	Difference coverage of econumber (%)		**1.7**	**-**	**-**	**3.1**	**0.5**	**-9.8**	**3.9**	**0.1**	**0.4**	**-**

Furthermore, indifferent species dominated in the entries, which were in the older records represented by: *Acer platanoides, Carpinus betulus, Galium aparine, Geranium robertianum, Mercurialis perennis, Quercus robur, Ulmus minor*. To the new indifferent species in the forest coppice were added: *Calamagrostis epigejos, Fraxinus excelsior, Viburnum opulus* and on the clearcut PRP *Cirsium arvense, Serratula tinctoria, Vicia angustifolia*.

The species of the econumber 4 (indicators between drought and fresh soils) are of a high percentage ratio in all records. In the older entries these are represented by the species: *Lithospermum purpurocaeruleum, Convallaria majalis, Cornus mas, Euonymus verrucosus, Hypericum perforatum, Ligustrum vulgare, Melica nutans, Melittis melissophyllum, Quercus cerris, Rhamnus catharticus, Robinia pseudoacacia, Rosa canina, Sorbus torminalis, Viburnum lantana, Vicia pisiformis*. In the forest coppice percentage ratio of this econumber significantly increased and new species were added *Crataegus monogyna, Lonicera caprifolium, Prunus spinosa, Securigera varia, Veronica officinalis, Viola riviniana*. Moreover, to the clearcut PRP there were added *Achillea millefolium, Amaranthus retroflexus, Astragalus glycyphyllos, Campanula rapunculoides, Carduus acanthoides, Clinopodium vulgare, Crataegus monogyna, Inula conyzae, Linaria vulgaris, Prunus spinosa, Securigera varia, Silene latifolia ssp. alba, Veronica officinalis, Viola riviniana*.

To the species of the econumber 6 (indicator between fresh and moist soils) in the older records belonged: *Ajuga reptans, Anemone ranunculoides, Campanula trachelium, Cruciata laevipes, Lamium maculatum, Roegneria canina*, *Scrophularia nodosa, Tilia platyphyllos, Urtica dioica.* To the forest PRP species were added, namely *Corydalis cava, Gagea lutea, Glechoma hederacea, Roegneria canina* and on the clearcut PRP the following were the species *Artemisia vulgaris, Aster lanceolatus, Corydalis cava, Gagea lutea, Glechoma hederacea, Roegneria canina, Tussilago farfara.* The smallest percentage ratio in all records is reached by the species of the econumber 3 (indicator of drought) in the older records this econumber is represented by two species, namely *Lathyrus niger* and *Tithymalus cyparissias*. In the forest records there are species *Quercus pubescens* and *Viola hirta* and on clearcuts this econumber 3 is presented by *Ajuga genevensis* and *Holosteum umbellatum*.

Only on the clearcut PRP the species of the econumber 7 (indicator of moist soil) occur – *Carex ovalis* and 8 (indicator between moist and wet soil) – *Cirsium canum, Humulus lupulus, Solanum dulcamara*. The econumber 1 (indicator of extremely dry soil), 2 (indicator between extremely dry and dry soil) and 9 (indicator of wet soil) do not occur.

Within the ecofactor 'effect of pH' to the most widespread species of the older records '1968–1969' belong indifferent species *Acer platanoides, Carpinus betulus, Convallaria majalis, Dactylis glomerata, Geranium robertianum, Geum urbanum, Hedera helix, Heracleum sphondylium, Chaerophyllum temulum, Melica nutans, Mycelis muralis, Quercus robur, Robinia pseudacacia, Rosa canina, Tilia platyphyllos, Tithymalus cyparissias, Viola odorata* (Table 5). In the forest PRP indifferent species are absent *Heracleum sphondylium, Chaerophyllum temulum, Melica nutans, Mycelis muralis, Rosa canina, Tilia platyphyllos* and *Tithymalus cyparissias*. On the clearcuts the following taxa are absent *Heracleum sphondylium, Mycelis muralis* and *Tilia platyphyllos*.

T a b l e 5. Significance of changes in percentage coverage of Ellenberg indicator values (econumbers) for factor „effect of pH" (according to Ellenberg, 1992).

Ecofactor		Econumber	x	1	2	3	4	5	6	7	8	9
Effect of pH	1968/69	Coverage of econumber (%)	33.8	-	-	-	-	3.6	19.7	25.6	17.3	-
	2013-forest cover		24	-	-	0.2	0.1	0.4	14.3	33.5	28	0.1
	Difference coverage of econumber (%)		**-9.8**	**-**	**-**	**0.2**	**0.1**	**-3.2**	**-5.4**	**7.9**	**10.7**	**0.1**
Effect of pH	1968/69	Coverage of econumber (%)	33.8	-	-	-	-	3.6	19.7	25.6	17.3	-
	2013-clearcut		32.5	-	-	0.1	0.1	1.3	13	32.1	20	0.9
	Difference coverage of econumber (%)		**-1.3**	**-**	**-**	**0.1**	**0.1**	**-2.4**	**-6.7**	**6.5**	**2.7**	**0.9**

Largely widespread in the older records are the species of the econumber 6 (indicators between acidic and weakly acidic up to alkaline conditions) – *Ajuga reptans, Brachypodium sylvaticum, Cruciata laevipes, Fragaria moschata, Galium aparine, Galium odoratum, Hypericum perforatum, Melica uniflora, Melittis melissophyllum, Polygonatum multiflorum, Quercus cerris, Scrophularia nodosa* and 7 (indicators of weakly acidic up to alkaline conditions) – *Acer campestre, Alliaria petiolata, Bromus benekenii, Cerasus avium, Crataegus laevigata, Dentaria bulbifera, Epipactis helleborine, Euonymus verrucosus, Galeobdolon luteum, Lamium maculatum, Lathyrus niger, Lithospermum purpurocaeruleum, Roegneria canina, Sorbus torminalis, Urtica dioica, Viola reichenbachiana*.

On PRP of the forest coppice in '2013' absent: *Cruciata laevipes, Fragaria moschata, Hypericum perforatum, Melittis melissophyllum, Scrophularia nodosa* (econumber 6), *Epipactis helleborine, Lathyrus niger, Lithospermum purpurocaeruleum, Roegneria canina,* (econumber 7). On the clearcut PRP, on the other hand, significantly rises the number of species of these econumbers, namely *Carex sylvatica, Dactylis polygama, Humulus lupulus* (econumber 6), *Ailanthus altissima, Ajuga genevensis, Amaranthus retroflexus, Arctium lappa, Astragalus glycyphyllos, Campanula rapunculoides, Cirsium canum, Cirsium vulgare, Clematis vitalba, Clinopodium vulgare, Swida sanguinea, Corydalis solida, Roegneria canina, Gagea lutea, Inula*

conyzae, Lamium purpureum, Linaria vulgaris, Lonicera xylosteum, Prunus spinosa, Serratula tinctoria, Sonchus arvensis, Vinca minor (econumber 7).

A high percentage ratio also presents the econumber 8 (taxa between weakly acidic up to weakly alkaline and basic and calcareous soil) in the older records these were presented by taxa: *Anemone ranunculoides, Campanula trachelium, Cornus mas, Euonymus europaeus, Lathyrus vernus, Ligustrum vulgare, Mercurialis perennis, Pulmonaria officinalis, Rhamnus catharticus, Sanicula europaea, Torilis japonica, Ulmus minor, Viburnum lantana, Vicia pisiformis, Viola mirabilis*. In the forest PRP in 2013, the following species were added: *Corydalis cava, Crataegus monogyna, Lonicera caprifolium, Viola hirta*. On the clearcuts it also comes to an increase of species, namely *Arctium tomentosum, Carduus acanthoides, Corydalis cava, Crataegus monogyna, Hypericum hirsutum, Chenopodium hybridum, Sambucus ebulus, Tussilago farfara, Viola hirta.*

With a small percentage ratio the species of the econumber 5 (slightly acidic conditions) are presented. In the older entries these are *Carex pilosa, Milium effusum, Poa nemoralis*. In the new records '2013' on PRP of the forest coppice and on clearcut PRP the same species occur; however, in a different abundance. Only in the forest coppice and on clearcuts the species of the econumber 3 (indicators of acidic conditions) occur, namely *Veronica officinalis* in the forest coppice and *Carex ovalis* and also *Veronica officinalis* on the clearcuts. Furthermore, also the species of the econumber 4 occur here (indicators between acidic and slightly acidic conditions) – *Viola riviniana* and of the econumber 9 (indicators of basic and calcareous soil) – *Securigera varia* in the forest as well as on the clearcut PRP. Indicators of strongly acidic (econumber 1) and indicators between strongly acidic and acidic conditions (econumber 2) are not presented in the records.

Within the ecofactor 'nitrogen' in the older records '1968/1969' with the highest percentage ratio there occur indifferent species that are represented by *Acer platanoides, Carpinus betulus, Hedera helix, Quercus cerris, Q. robur, Rosa canina, Ulmus minor, Viola mirabilis*. In the forest records of '2013' new taxa are added: *Prunus spinosa, Quercus pubescens, Swida sanguinea, Viola riviniana.* On the clearcut PRP addition of new species does not happen (Table 6).

T a b l e 6. Significance of changes in percentage coverage of Ellenberg indicator values (econumbers) for factor „nitrogen" (according to Ellenberg, 1992).

Ecofactor		Econumber	x	1	2	3	4	5	6	7	8	9
Nitrogen	1968/69	Coverage of econumber (%)	25	-	-	4.4	10.4	18	23.9	6.6	9	2.7
	2013-forest cover		26.7	-	0.01	4.9	11.6	11	22	13	8	2.7
	Difference coverage of econumber (%)		**1.7**	**-**	**0.01**	**0.5**	**1.2**	**-7**	**-1.9**	**6.4**	**-1**	**0**
Nitrogen	1968/69	Coverage of econumber (%)	25	-	-	4.4	10.4	18	23.9	6.6	9	2.7
	2013-clearcut		19.9	-	0.7	10.6	2.9	8.9	17	17.6	15.5	7.1
	Difference coverage of econumber (%)		**-5.1**	**-**	**0.7**	**6.2**	**-7.5**	**-9.1**	**-6.9**	**11**	**6.5**	**- 4.4**

A high percentage ratio in the older records have the econumber 5 (indicators of soils averagely nitrogen-rich) and 6 (indicators between averagely nitrogen-rich soil and rather rich habitats). To the given taxa of these econumbers belong: *Bromus benekenii, Carex pilosa,*

Cerasus avium, Crataegus laevigata, Epipactis helleborine, Euonymus europaeus, Galeobdolon luteum, Galium odoratum, Milium effusum, Polygonatum multiflorum, (econumber 5), *Acer campestre, Ajuga reptans, Brachypodium sylvaticum, Dactylis glomerata, Dentaria bulbifera, Fragaria moschata, Melica uniflora, Mycelis muralis, Pulmonaria officinalis, Sanicula europaea, Viola reichenbachiana* (econumber 6). In the forest coppice it comes to a decrease in the percentage ratio of the given econumbers and these taxa are absent: *Epipactis helleborine* (econumber 5), *Fragaria moschata, Mycelis muralis* (econumber 6). On the clearcuts the following species are absent: *Cerasus avium, Epipactis helleborine,* (econumber 5), *Mycelis muralis, Sanicula europaea* (econumber 6).

Another widespread species are taxa of the econumbers 4 (soils between rather poor and averagely nitrogen-rich) and 8 (explicit indicators of nitrogen). To the given species in the older records belong: *Convallaria majalis, Cornus mas, Hypericum perforatum, Lathyrus vernus, Lithospermum purpurocaeruleum, Poa nemoralis, Rhamnus catharticus, Sorbus torminalis, Viburnum lantana* (econumber 4), *Roegneria canina, Anemone ranunculoides, Campanula trachelium, Galium aparine, Heracleum sphondylium, Chaerophyllum temulum, Lamium maculatum, Robinia pseudoacacia, Torilis japonica, Viola odorata* (econumber 8). To PRP in the forest coppice these species of the econumber 4 are added *Crataegus monogyna* and *Veronica officinalis* and, on the other hand, species of the econumber 8 wane *Campanula trachelium, Heracleum sphondylium, Roegneria canina* and *Torilis japonica*. On the clearcut PRP the following species are absent *Lathyrus vernus, Rhamnus catharticus, Sorbus torminalis* (econumber 4) and, on the other hand, *Ailanthus altissima, Artemisia vulgaris, Aster lanceolatus, Ballota nigra, Cirsium vulgare, Corydalis cava, Echinochloa crus-galli, Humulus lupulus, Chenopodium hybridum, Roegneria canina, Solanum dulcamara, Taraxacum sect. Ruderalia* (econumber 8) are added.

To the species that occur in the old records belong also the species of the econumber 3 (rather nitrogen-poor) and 7 (rather nitrogen-rich habitats), namely the species: *Euonymus verrucosus, Lathyrus niger, Ligustrum vulgare, Melica nutans, Melittis melissophyllum, Vicia pisiformis, Tithymalus cyparissia,* (econumber 3), *Cruciata laevipes, Geranium robertianum, Geum urbanum, Mercurialis perennis, Scrophularia nodosa, Tilia platyphyllos* (econumber 7). To the forest coppice there are added species: *Securigera varia, Viola hirta* (econumber 3), *Corydalis solida, Fallopia dumetorum, Fraxinus excelsior, Gagea lutea, Glechoma hederacea* (econumber 7) and to the clearcut PRP are added *Astragalus glycyphyllos, Carex ovalis, Clinopodium vulgare, Inula conyzae, Securigera varia, Serratula tinctoria, Viola hirta* (econumber 3), *Amaranthus retroflexus, Carduus acanthoides, Cirsium arvense, Clematis vitalba, Corydalis solida, Fallopia dumetorum, Gagea lutea, Glechoma hederacea, Hypericum hirsutum, Lamium purpureum, Lavatera thuringiaca, Sambucus ebulus, Silene latifolia ssp. alba* (econumber 7).

To the species that represent the econumber 9 (above average nitrogen-rich soil) in the old records the following taxa belonged *Alliaria petiolata* and *Urtica dioica*, within the forest and clearcut PRP it is the species *Urtica dioica*. In the older records the species of the ecofactor 2 do not occur (species between the poorest and rather nitrogen-poor), in the forest PRP this econumber represents *Lonicera caprifolium* and on the clearcut PRP this econumber represent two species: *Ajuga genevensis* and *Holosteum umbellatum*. The species of the ecofactor 1 (nitrogen-poorest) do not occur in the records.

Discussion

On the basis of the results it is possible to state that it has come to a significant change within the percentage ratio of the econumbers of the ecofactor 'light'. The reason for this significant change is a different management, i.e. the reason is the anthropogenic disturbance. In 2006 four clearcuts were established, indigenous forest vegetation was removed and also in the forest lines, between the clearcuts, it came to the thinning of vegetation due to shelter-wood logging. In the forest vegetation in the NNR the Báb forest and in the forest lines shade-demanding and half shade taxa decrease; however, this change is minimal. A bigger change is in the increase of the species of the econumber 6 which are species indicating half shade and half sun. To these species belong, e.g. *Fallopia dumetorum, Roegneria canina, Veronica officinalis, Viola hirta.* The given species were not presented in the old entries. Species have bigger abundance mainly in the forest lines due to the thinning by the shelter-wood logging; and therefore, due to the creation of more propitious light conditions.

A striking change occurs when comparing the older records '1968/1969' with the clearcut records '2013' within this ecofactor. Certainly, this is a presumed change. Due to clearcutting way of logging a great thinning appears. Even though, on the clearcuts also shade-demanding forest species occur; however, the amount of photophilous synanthropic and clearcut species significantly increase. To the clearcut species, the modified habitat now more exposed to light satisfy, belong: *Urtica dioica*, *Tithymalus cyparissias*, *Solanum dulcamara*, *Lactuca serriola*, *Achillea millefolium*, *Ajuga genevensis*, *A. reptans*, *Astragalus glycyphyllos*, *Ballota nigra*, *Cirsium arvense*, *C. vulgare*, *Linaria vulgaris*, *Arctium lappa*, *A. tomentosum, Artemisia vulgaris* and woody plants of forest shroud, such as *Sambucus nigra* and *Rosa canina* (Pilková, 2013; Ferlíková, 2009, 2011). Many of these species also occur in the older entries; however, they reach only a very small, negligible, abundance; and therefore, these were not percentage manifested. On the clearcuts mainly species of the econumber 8 increased which are photophilous taxa. These species reach a very high abundance which is the result of the free space, free ecological niche and lighting after the logging in 2006.

To the most serious environmental problems nowadays belong the global warming and possible climatic changes. Current state of the weather during the last two decades with more often and more intensive fluctuations of extreme weather persuades us that we witness the already begun climatic changes. Finally, also climatic measurements during the last 100 years in Slovakia verify the trend of the average annual temperature increase of 1.1 °C and decrease of annual rainfall in average of 5.6% (Balajka et al., 2005). Forests, as one of the most crucial components of the environment are in direct impact of this problem (Špánik et al., 1999).

For the factor 'temperature' which might, from the point of view of the already mentioned climatic changes influence, show certain trends, there were only weak and various changes in particular vegetative levels recorded (Vladovič et al., 2008). Moreover, also on PRP in the forest coppice this change does not reach a more significant number. On this forest, PRP the ratio of the econumber 5 has decreased and the ratio of the econumber 6 has more significantly increased. This econumber is presented by the species, such as *Corydalis cava*, *C. solida*, *Fallopia dumetorum*, *Impatiens parviflora*, *Roegneria canina*, *Securigera varia*, *Vinca minor*. From the spring geophytes, we may assume that these also occurred in 1968–1969. However,

the entries were probably not written during the spring period. In the older records almost all spring geophytes absent that change the percentage ratio of the particular econumbers in a significant way.

To the new species that are intensively spreading belong *Impatiens parviflora* and *Vinca minor*. The invasive herb *Impatiens parviflora* was at the beginning of the 1980s introduced to the park and in the half 1980s it permeated to the forest coppice in the surroundings of the field laboratory. With the support of people, it also spread to the more distant forest parts (Eliáš, 2010) and the species *Vinca minor* was presumably spread from the nearby PA the Báb park. On the basis of these statements, it is not possible to claim that the change happened due to the increase of temperature; however, due to human disturbance by the introduction. Further, it happened due to advantageous ways of spreading of the given non-indigenous species and spreading of the clearcut species mainly to the forest lines thinned due to shelter-wood logging.

An intensive increase of the econumber 6 is observed mainly on the clearcuts where mainly the following taxa occur with a big abundance: *Arctium lappa*, *Glechoma hederacea*, *Hypericum hirsutum*, *Inula conyzae*, *Linaria vulgaris*, *Roegneria canina*, *Sambucus ebulus*, *Viola odorata*, i.e. the species presenting synanthropic and clearcut taxa. Difference in other ratios of the econumbers is not significant. A bigger change is within the comparison of the indifferent species. However, the change is not caused by the occurrence or abundance of the taxa of the given econumber, but by the fact that in the older records they almost do not occur in spring species. This fact is then reflected in the percentage ratio as it is already stated above.

Within the ecofactor 'continentality' there is a significant change only by the suboceanic taxa; there is an increase on PRP in the forest coppice and on the other hand, a decrease on PRP on the clearcuts. To the forest coppice the following species were added: *Corydalis cava* and *Gagea lutea* as significant representants of a spring period; *Fallopia dumetorum* as a species spreading from the clearcuts and further new species, *Lonicera caprifolium*, *Quercus pubescens* and *Swida sanguinea*. The species *Lonicera caprifolium* has spread to the forest presumably from the park where it grows as an ornamental species. On the clearcuts there was absent species *Lathyrus niger*, *L. vernus*, *Sorbus torminalis*, *Vicia pisiformis*, i.e. the species that were eliminated due to the logging. There is an assumption that due to overgrowing of the clearcuts and the creation of more ideal conditions these species will spread here again.

After evaluating the ecofactor 'moisture' we state that the ratio of indicators of fresh soil has significantly decreased. On PRP of the forest coppice and on the clearcuts these species absent *Epipactis helleborine*, *Heracleum sphondylium*, *Chaerophyllum temulum*, *Mycelis muralis*, *Torilis japonica*, *Cerasus avium*, *Lathyrus vernus*, *Sanicula europaea.* Most of these species has not been recorded during the new record that was reflected in the change of the percentage ratio of the given econumber. The change in the percentage ratio of the other econumbers is not significant.

Within the ecofactor 'effect of pH' it came in 2013 to a decrease of acidophilous species and on the other hand, the percentage ratio of the econumbers 7 and 8 increased which represent conditions weakly acidic up to basic. To the PRP in the forest coppice in '2013' was added *Corydalis cava*, *Crataegus monogyna*, *Lonicera caprifolium* and *Viola hirta*. The given species achieve a high abundance. On the clearcut PRP these species considerably increased *Ailan-*

thus altissima, *Ajuga genevensis*, *Arctium lappa*, *Cirsium canum*, *C. vulgare*, *Corydalis cava*, *C. solida*, *Roegneria canina*, *Gagea lutea*, *Inula conyzae*, *Lamium purpureum*, *Linaria vulgaris*, *Carduus acanthoides*, *Crataegus monogyna*, *Hypericum hirsutum*, *Sambucus ebulus*. The hereinbefore stated results do not concur with the work by Szombatová and Zaujec (2001), who did the research on the slight slope of the Báb forest. The authors claim that it comes to an acidification in comparison with the older data. On the other hand, the results concur with the work by Vladovič et al. (2008). The authors claim that changes in the species composition of herbs shown in their results indicate a nitrification of 1st, 2nd and partly 3rd vegetative level.

By evaluating the ecofactor 'nitrogen' we observe an increase of taxa that like nitrogen-rich posts and on the other hand, a decrease of taxa of average and nitrogen-poor soil. To the forest coppice species were added: *Corydalis solida*, *Fallopia dumetorum*, *Fraxinus excelsior*, *Gagea lutea*, *Glechoma hederacea*. To the clearcut PRP were added *Carduus acanthoides*, *Cirsium arvense*, *Glechoma hederacea*, *Hypericum hirsutum*, *Lamium purpureum* and *Sambucus ebulus.* In the forest coppice mainly the forest species are widespread and on the clearcuts synanthropic and clearcut species that are typical for places with a higher content of nitrogen. These are the species which did not occur in the older records; and therefore, a change in the percentage ratio of the econumbers of the given ecofactor appears.

Conclusion

The environment changes are shown in the comparison of the ratio of the econumber of the ecofactors 'light, temperature, moisture, continentality, effect of pH and nitrogen.' The percentage ratio of the econumbers is counted from the phytocenological records from the years 1968–1969 and 2013, where PRP are located in the forest coppice and on the clearcuts.

In 2006, it came to the establishment of clearcuts and in the forest lines, between the clearcuts, thinning of the coppice was done due to the shelter-wood logging. On the basis of this change it comes to a significant change within the ratio of the econumbers of the ecofactors 'light' and 'temperature'. An increase of photophilous and thermophilic species appears. Within the ecofactor 'continentality' an increase of suboceanic taxa on PRP in the forest coppice appears. And within the ecofactor 'moisture' the ratio of indicators of fresh soil has significantly decreased. In 2013, a decrease of acidophilous species and an increase of taxa that like nitrogen-rich habitats appear.

We may state that the change of the econumbers ratio of the observed ecofactors, between the records of 1968–1969 and 2013, happens mainly because of a different management. It is the clearcut establishment, removal of indigenous forest vegetation; and therefore, it comes to an occupation of the free space by synanthropic, clearcut and invasive species. Most of these species represent thermophilic, photophilous taxa and representants of nitrogen-rich soil. And therefore, there is a big change observed on the clearcuts when compared to the year 1968–1969. The change is also documented in the PRP forest coppice records; however, not so markedly. Within the PRP in the forest coppice new species occur, such as spring geophytes, non-indigenous species and spread taxa from the clearcuts. These taxa show a high abundance during the spring as well as summer records; and therefore, influenced the ratio of the econumbers of the six observed ecofactors.

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