BRC
www.brc.amu.edu.pl

Biodiv. Res. Conserv. 1-2: 114-122, 2006

Dynamics of a small clearing flora in the biodiversity context

Stanisław Balcerkiewicz* & Grażyna Pawlak

Department of Plant Ecology and Environment Protection, Adam Mickiewicz University, Umultowska 89, 61-614 Poznań, Poland, *e-mail: balc@amu.edu.pl

Abstract: The present study forms a part of a multifaceted research project exploring the rate and directions of spontaneous dynamics of vegetation cover after the cessation of agricultural use, as well as the effects of anthropogenic modification of this process through controlled mowing and ploughing. Results are based on data from the experimental site located in the Wielkopolski National Park and consisting of 135 permanent 5 m × 5 m square plots. Observations in all plots were regularly repeated at 5 year intervals and, in selected plots, at additional times. The documentation covers the period from 1976 to 2003 and consists of 49675 singular floristic data entries. The objective of this work was to determine which elements of the local flora dynamics may be revealed through systematically repeated observations of permanent plots. We also aimed to understand the influence of spontaneous succession and simple agronomic treatments on the development of local biological diversity.
The current paper presents the dynamics of floristic richness and diversity of a small forest clearing flora in a spatial and temporal aspect over a 25 year period. At the time of initiation of the experiment, the flora of the clearing was homogenous and dominated by segetal elements. Currently, the vegetation cover of the clearing is strongly diversified. Apart from segetal communities, there occur phytocoenoses representing fallow field, meadow, sward, forest edge and juvenile woodland stages. Over 25 years (1978-2003) this small (0.5 ha) area was inhabited by 251 species of vascular plants, including 20 species of trees and 13 species of shrubs. Ninety species have survived from 1978 and 134 species have been added since then.

Key words: floristic dynamics, biological diversity, geobotanical experiment, permanent plots, Wielkopolski National Park, Poland

ECOLOGY

1. Introduction

As noted by Weiner (1999) "research on diversity, such as cataloguing species, monitoring changes in the composition of flora and fauna, theoretical and experimental work on the development and functioning of organismal groups including the significance of their diversity, is currently being undertaken throughout the world". The present study belongs to this research trend. It must be noted, however, that it represents only a small segment of a multifaceted research project aimed at understanding the rate and directions of vegetation dynamics after the abandonment of agricultural use, as well as the effects of anthropogenic modifications of this process through mowing or ploughing. While the whole endeavour is experimental and is directed mainly at phytocoenotic questions, this article presents only selected floristic aspects. It should be clarified that in the case of a small clearing flora mentioned in the title, the flora concept is used in a very narrow, local, spatially limited sense.

Our interest in the flora of this small (0.5 ha) area was stimulated by the possession of our own data from regular long term (25 year) observations of permanent plots. This kind of material allows to address the spatial differentiation of the flora as well as its changes through time. Another significant motivation for this study was the opportunity to compare the floristic richness of the clearing to the flora of the entire Wielkopolski National Park (Żukowski *et al.* 1995).

The purpose of this research was to reveal some aspects of the dynamics of a very small land area. An attempt was made to understand the influence of spontaneous succession and simple agronomic operations on the development of local species diversity.

2. Material and methods

This research is based on a permanent area situated in a small (~0.5 ha) forest clearing within the Wielkopolski National Park (forest subdivision 82d).

The clearing used as the experimental area (and, at the same time, forming the biochore of the flora) is located in an oak-hornbeam forest *Galio sylvatici-Carpinetum* (R. Tx. 1937) Oberd. 1957, and surrounded by the same forest type. The study area has been subdivided into 135 permanently marked 5 m × 5 m square plots arranged in 15 rows of 9 plots each. The location of specific experiments and experimental treatments is shown in Fig. 1. Human pressure has been entirely excluded from over half (3/5) of the experimental area. The remainder of the area has been subjected to ploughing and harrowing, or mowing. These agronomic operations were conducted regularly from the beginning of the experiment, i.e. from 1978 till present, with the timing and frequencies constituting experimental treatments. It should be clearly pointed out that in the ploughed plots no crops have been grown and no fertilization has been applied. Tilling has constituted the only kind of anthropic pressure.

Until 1976, the clearing (the present research area) was utilized as a game feeding lot and was planted with oats and yellow lupin. In the autumn 1976, the first phytosociological documentation was collected, and subsequently the entire area was evenly ploughed and harrowed. These operations were repeated in 1977 and in the spring 1978, when individual base plots were permanently marked. Thus, 1978 was the starting year for the entire research program (Balcerkiewicz & Pawlak 2001).

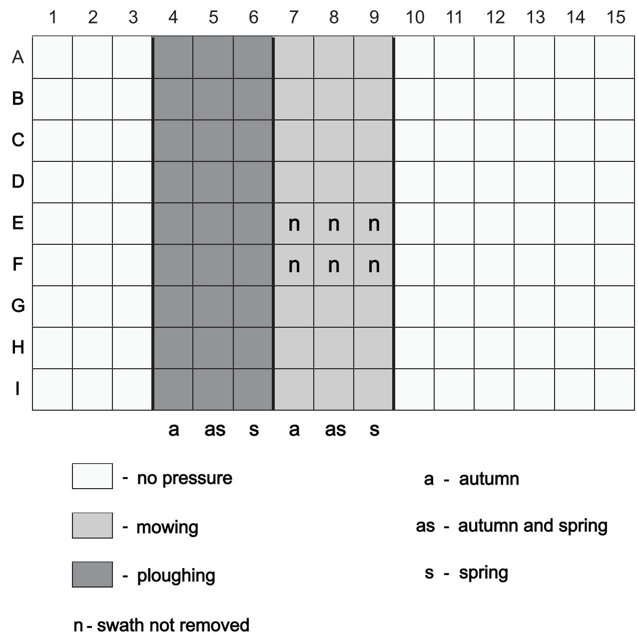

Fig. 1. Layout of the permanent study site

Geobotanical documentation was gathered every 5 years for each of the 135 individual plots, and, in addition, every year for preselected plots. The main form of data collection were phytosociological reléves obtained by the Braun-Blanquet's method (Braun-Blanquet 1964; Dierschke 1994). Cartographic methods were also used, and for selected species individual densities were evaluated. Materials utilized in this article cover years 1976-2003 and consist of 49675 singular floristic data entries. The data have been archived in data bases of the *Profit* software package (Balcerkiewicz & Sławnikowski 1998). Programs of this package were also used to process most of the results presented here. Botanical nomenclature follows Mirek *et al.* (2002). Diversity was characterized on the basis of floristic richness, Simpson's dominance index (λ), Simpson's diversity index (D), and Shannon-Wiener diversity index (H) (Weiner 1999). These indices were calculated from the occurrence of species in base plots. Variability of these parameters was analyzed in both the spatial and temporal context.

3. Results

In the course of 25 years of study, 251 species of vascular plants were recorded in the clearing (Fig. 2). Of this number, 20 species were trees and 13 were shrubs. The largest number of species occurred in the 20th year of the experiment. Ninety species survived from the start of the experiment, and 134 new species were added. The original species make up only half of the present day species composition. The reasons for this are the exclusion of anthropic pressure in a part of the clearing and the diversification of anthropogenic influences in the remaining part. With time, the spectrum of floristic richness shows an increasingly clear correspondence with experimental treatments (Fig. 3). In the initial stage, numbers of taxa were relatively low and uniform. Only the marginal plots adjacent to the forest were somewhat richer. After 25 years, the differentiation of species richness was highest. Individual 25 m^2 plots contained from as few as 2, to as many as 74 taxa. The highest species numbers were recorded in the mowed plots. The fewest species

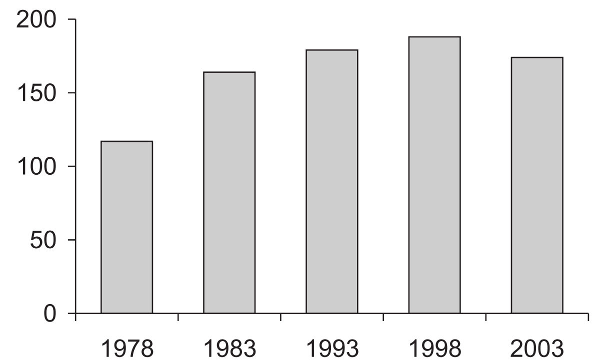

Fig. 2. Changes of species richness in the entire forest clearing throughout the 25 year period

1978 = 0 — 9-44; 23

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
A	40	36	28	18	28	23	22	20	32	25	31	30	33	43	40
B	30	22	16	14	21	18	15	10	18	17	18	17	21	27	34
C	29	18	19	13	24	19	10	11	13	12	16	15	23	29	37
D	39	21	19	17	16	17	15	9	14	17	18	19	22	31	34
E	27	24	24	16	22	22	11	9	13	15	20	20	22	28	34
F	25	25	24	16	25	21	17	15	17	19	20	18	23	34	34
G	37	28	27	27	29	25	18	17	17	21	22	16	22	31	39
H	32	28	25	26	25	20	16	17	19	23	20	19	21	28	35
I	44	35	38	29	29	33	16	20	20	29	32	27	30	30	28
				a	as	s	a	as	s						

1983 = 5 — 17-60; 32

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
A	33	33	36	25	29	37	44	52	60	31	36	17	34	49	52
B	25	19	15	20	24	24	36	45	37	27	22	21	27	40	47
C	29	17	28	20	24	20	29	43	34	29	24	32	31	36	45
D	33	21	22	23	23	30	41	48	35	26	26	30	31	33	35
E	31	27	23	28	28	27	41	47	39	27	27	30	33	29	33
F	28	25	30	28	26	25	34	30	29	29	23	29	37	33	34
G	29	27	34	31	29	30	39	39	40	27	27	26	32	28	33
H	33	23	25	33	37	32	41	44	36	22	24	25	24	20	31
I	38	26	31	42	40	44	53	56	36	25	31	32	31	31	27
				a	as	s	a	as	s						

1993 = 15 — 17-62; 38

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
A	34	30	34	41	35	48	58	53	60	32	40	35	30	33	36
B	31	31	33	39	32	39	51	59	54	32	37	38	39	38	42
C	34	33	36	39	37	44	51	54	54	44	37	44	38	37	37
D	42	33	35	38	35	44	53	54	57	41	32	39	37	37	39
E	39	37	27	45	40	39	44	54	51	31	24	38	36	31	30
F	31	36	37	47	39	40	38	50	37	28	26	31	34	30	27
G	34	36	39	45	43	46	49	62	59	31	25	27	32	29	24
H	29	26	30	53	43	47	52	53	53	23	17	22	23	19	22
I	34	29	27	54	54	47	60	58	41	24	24	27	21	30	32
				a	as	s	a	as	s						

2003 = 25 — 2-74; 27

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
A	16	7	24	50	32	51	62	58	65	36	9	5	3	2	3
B	2	2	17	40	37	36	46	51	65	27	6	4	3	3	4
C	8	4	15	36	35	39	47	58	52	28	6	3	2	4	2
D	15	5	20	40	32	35	56	53	64	26	3	3	4	3	5
E	21	3	17	39	32	32	39	45	48	25	9	3	11	13	11
F	16	5	15	40	34	35	47	42	39	27	10	8	15	16	15
G	23	9	25	43	36	38	66	58	63	29	16	16	18	24	21
H	19	17	27	41	38	43	74	56	41	30	14	19	21	26	20
I	20	19	23	39	38	44	64	68	52	20	21	21	21	26	17
				a	as	s	a	as	s						

Fig. 3. Spatial and temporal diversification of species richness
Explanations: Calendar year and duration of the experiment are given in the upper left hand corner. Minimal, maximal and average species numbers are in the upper right hand corner

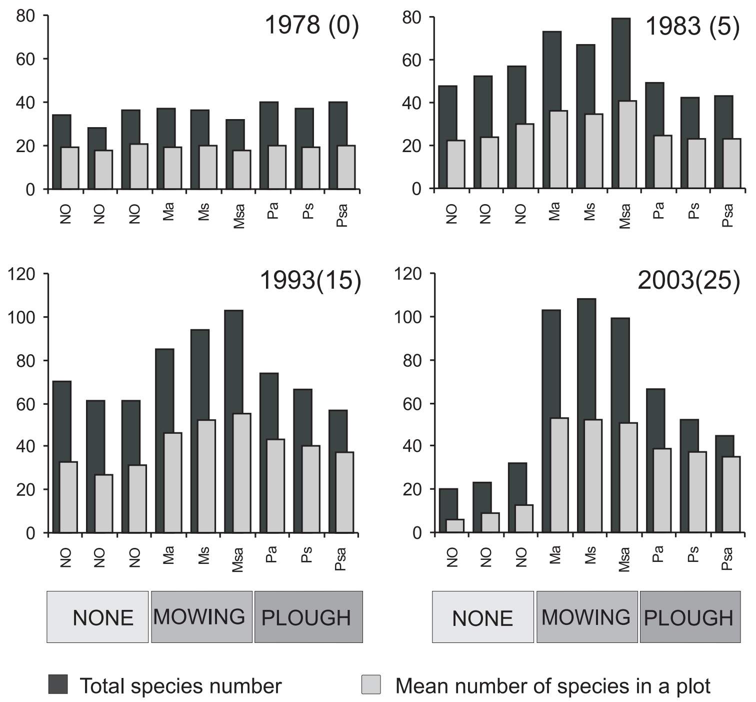

Fig. 4. Changes of species richness under different experimental treatments over 25 years
Explanations: NO – no pressure, Ma – mowing in autumn, Ms – mowing in spring, Msa – mowing in spring and autumn, Pa – ploughing in autumn, Ps – ploughing in spring, Psa – ploughing in spring and autumn

were found in thick hornbeam woodlands developed in sites from which all pressure had been excluded.

Differentiation and changes of floristic richness in the clearing are even more apparent when a synthetic approach is adopted, i.e. experimental treatments are considered in their entirety (Fig. 4), rather then analyzing individual plots. After a very uniform initial stage, the richness clearly increased already within the first 5 years of the experiment, regardless whether some form of pressure was applied or not. This increase was largest in mowed sites. This trend persisted for another 10 years. At 25 years after the initial stage, the number of species in sites isolated from pressure clearly decreased, in sites subjected to ploughing reached stabilization, and in mowed rows continued to grow, although slower increase was observed.

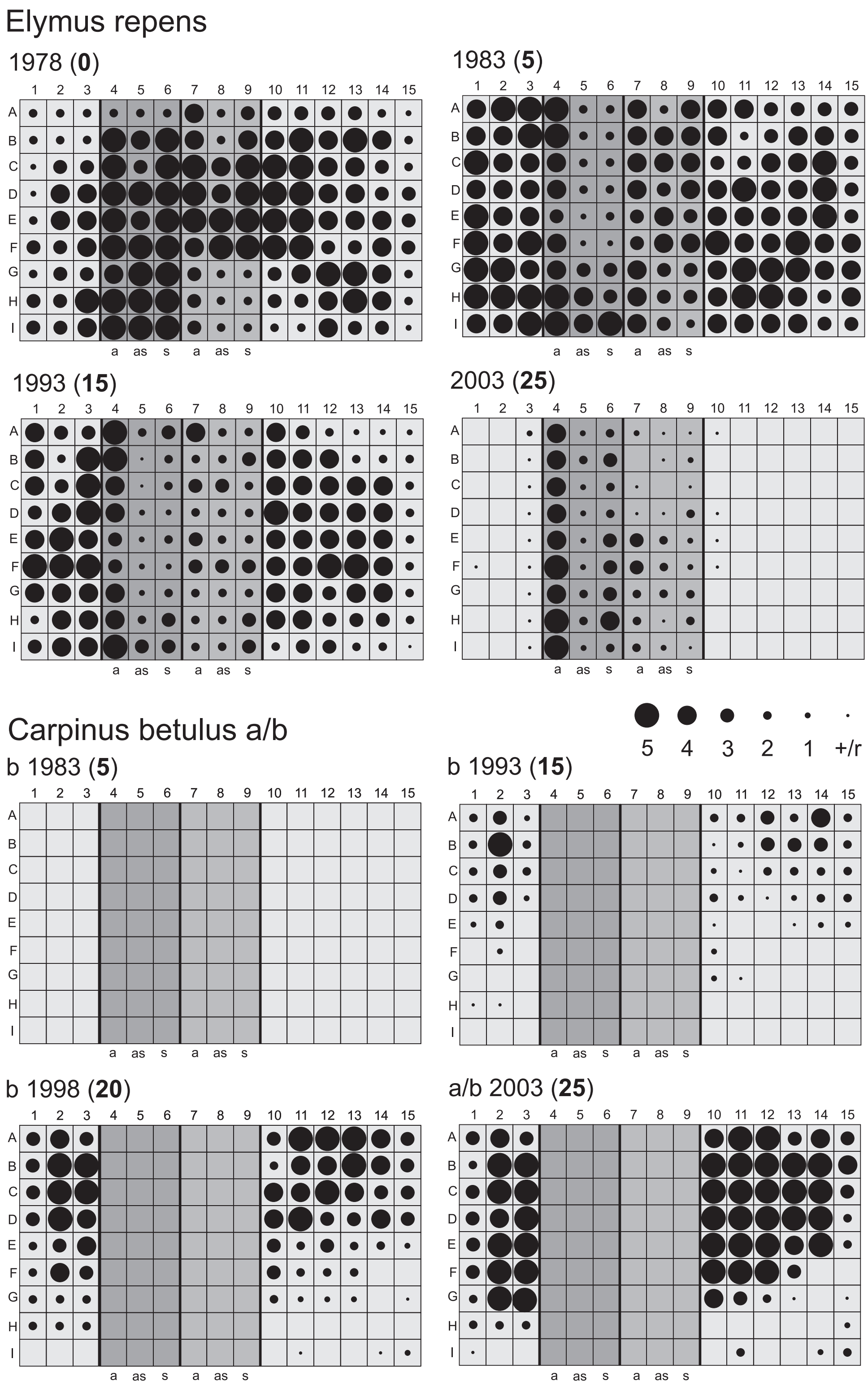

Fig. 5. Distribution and abundance of *Elymus repens* and *Carpinus betulus* (from shrub and tree layer) in several temporal profiles

Over the quarter century changes affected not only the floristic composition, but also the distribution and abundance of individual species (Figs. 5-8). This phenomenon is illustrated here using examples of selected species with different habitat and phytocoenotic preferences. The quackgrass *Elymus repens*, a plant characteristic of fallow land which originally dominated the entire area, was entirely eliminated in the process of uninhibited secondary succession. It was replaced as the absolute dominant by the hornbeam *Carpinus betulus*. On the other hand, the quackgrass found optimal conditions in sites ploughed only in the autumn (Fig. 5). The woodland fern *Dryopteris filix-mas*, which was absent at the start of the experiment, reached its quantitative optimum after 20 years. In plots excluded from use it even formed a luxuriant tall herb vegetation.

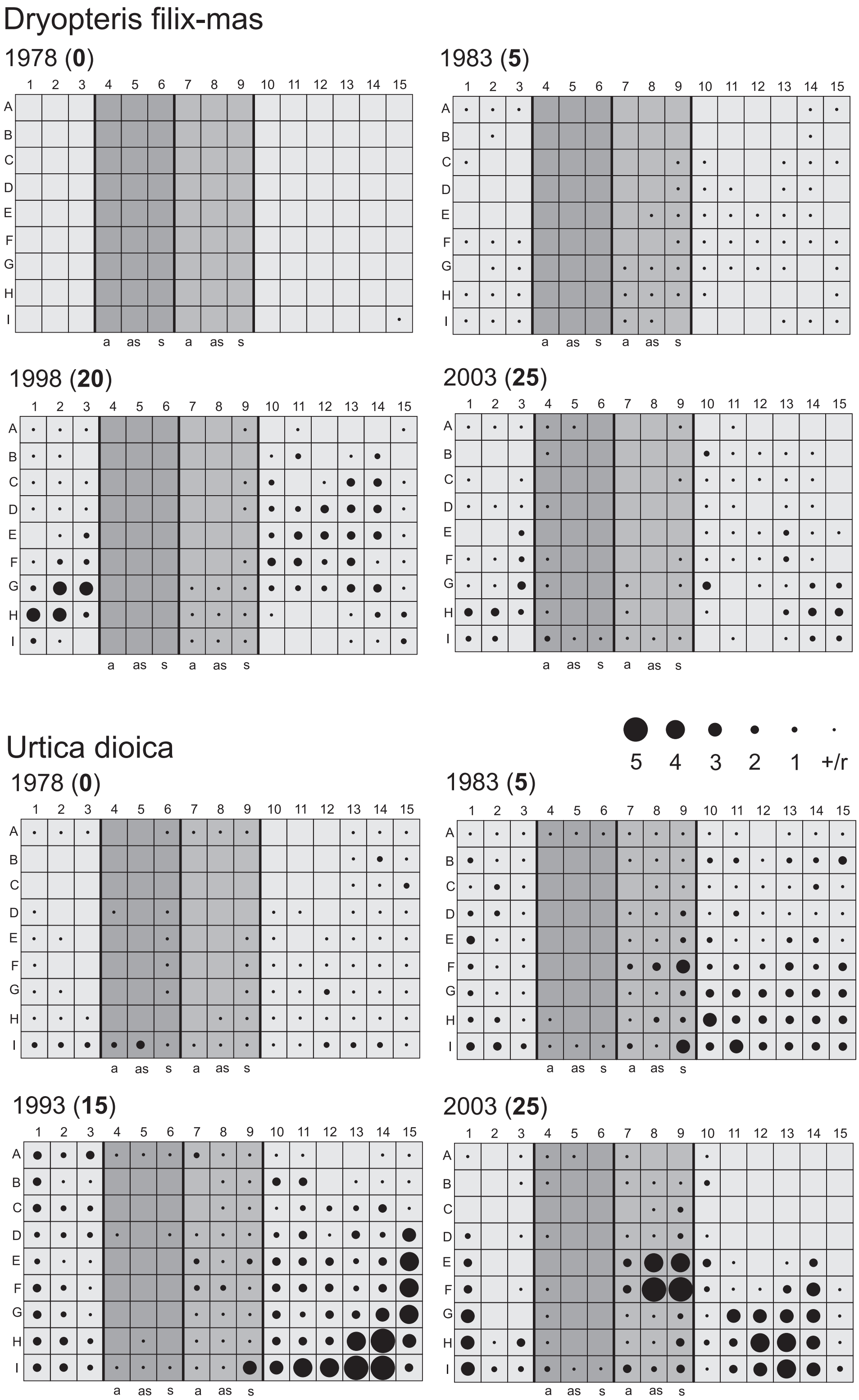

Fig. 6. Distribution and abundance of selected tall herbs, *Urtica dioica* and *Dryopteris filix-mas,* in several temporal profiles

At present, this fern is withdrawing due to the increasing thickness of the hornbeam woodland. A similar behavior is noted for another tall herb *Urtica dioica*. It appears that it may persist in abundance only in those plots where the swath is not removed (Fig. 6). The distribution and abundance of *Poa trivialis* demonstrate on the one hand that this species prefers mowed places, and on the other indicates the phytocoenotic connection of this grass with nitrophilous forest edge herbs. An outstanding attachment to conditions created by mowing is shown by *Holcus lanatus* (Fig. 7). The typical segetal plants quickly disappeared from sites in which tilling had ceased. They, however, persist, and even increase their share, in plots ploughed twice a year or only in the spring (Fig. 8).

The dynamics of the studied flora expressed in terms of dominance and diversity indices (Fig. 9). When the

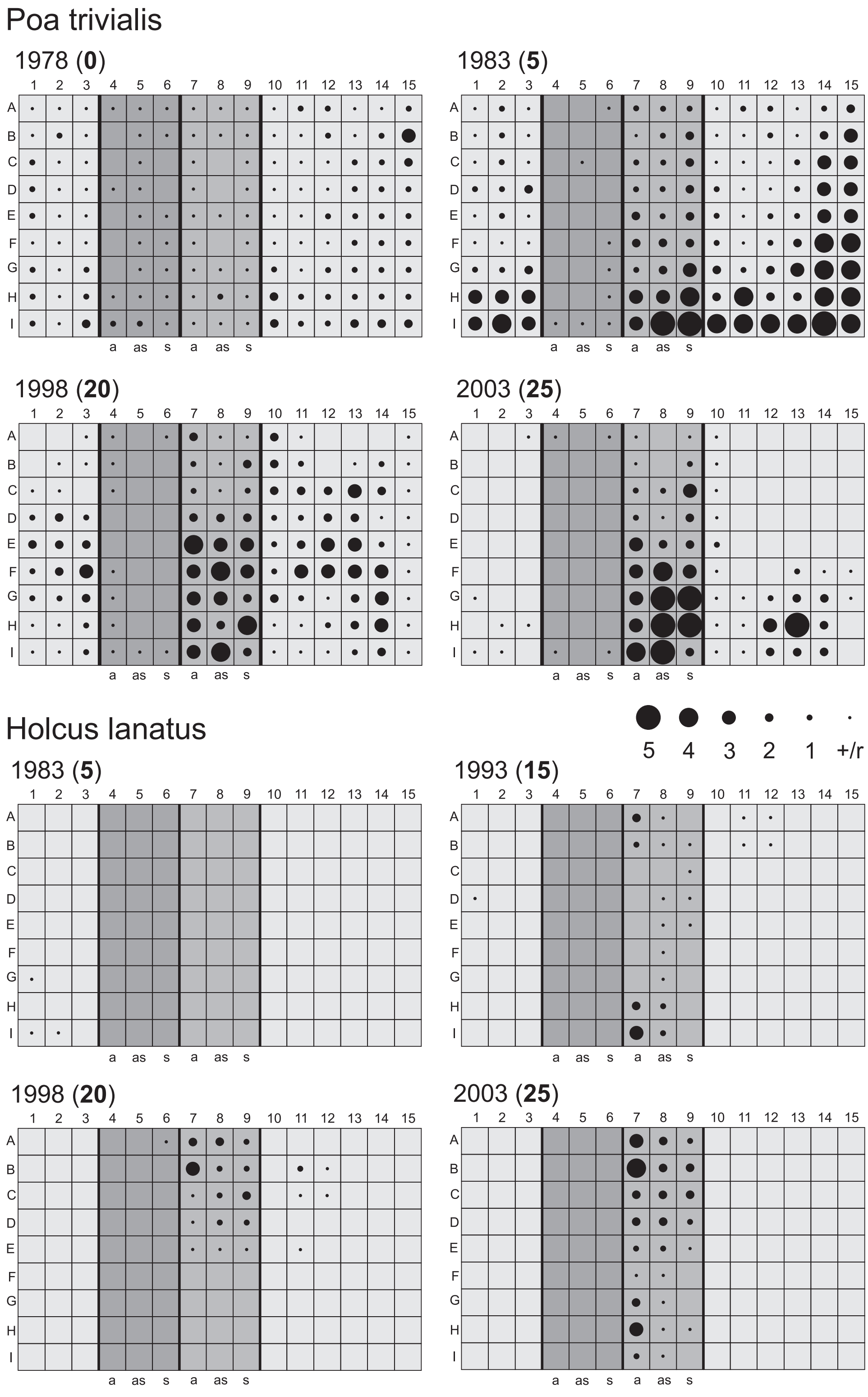

Fig. 7. Distribution and abundance of selected meadow species, *Poa trivialis* and *Holcus lanatus,* in several temporal profiles

flora of the clearing is considered en bloc, changes of these indices exhibit clearly unidirectional courses: a gradual decline of dominance indices and a rise of diversity indices. This tendency is not always confirmed when floras developed in particular experiments are viewed separately. In the situation of unconstrained succession, the increase of diversity which occurred during the first 15 years of the experiment was inhibited, and subsequently the diversity drastically declined. Causes for this state of matters might be attributed to peculiarities of juvenile forest communities which began to form after cessation of pressure. Patterns characteristic of endogenous forest dynamics, i.e. fluctuational changes, were superimposed on the processes of succession which had initially dominated. Mowing caused fast and significant growth of diversity. This

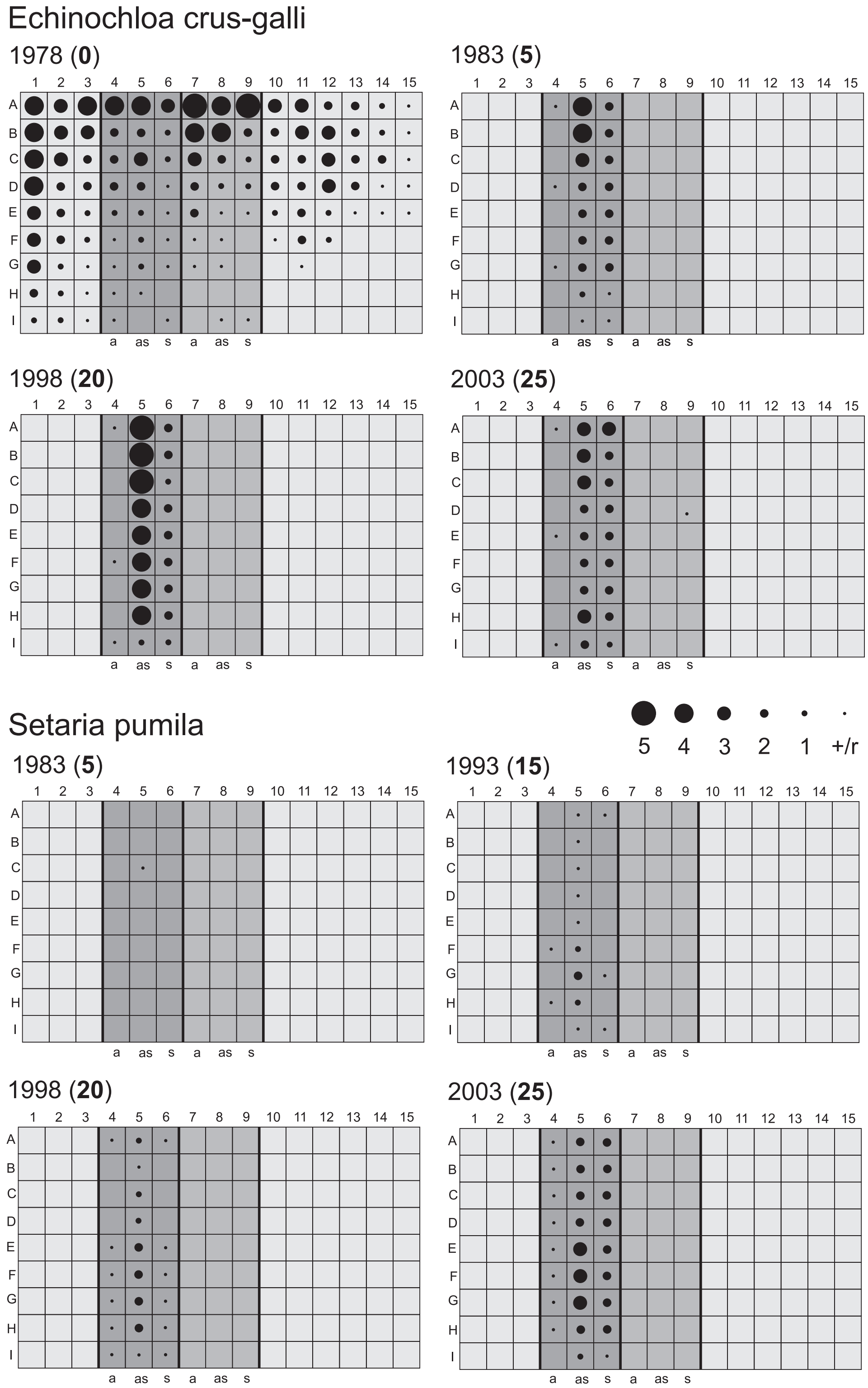

Fig. 8. Distribution and abundance of selected segetal species, *Echinochloa crus-galli* and *Setaria pumila,* in several temporal profiles

phenomenon is still continuing although at a reduced rate. Such situation could be considered characteristic of moderately constrained succession. The smallest changes of dominance and diversity index values were found for flora of the ploughed sites. This could have been expected, because that flora had predominantly developed already prior to the experiment, and currently it persists due to the application of a similar type of pressure.

4. Concluding remarks

Flora of even a small area is a very dynamic system, clearly responding to all changes of conditions. Its diversity can be relatively easily enriched, moulded and modified within broad limits. As a result of an experimental diversification of anthropic pressure, the uniform flora of the forest clearing soon underwent far-reaching

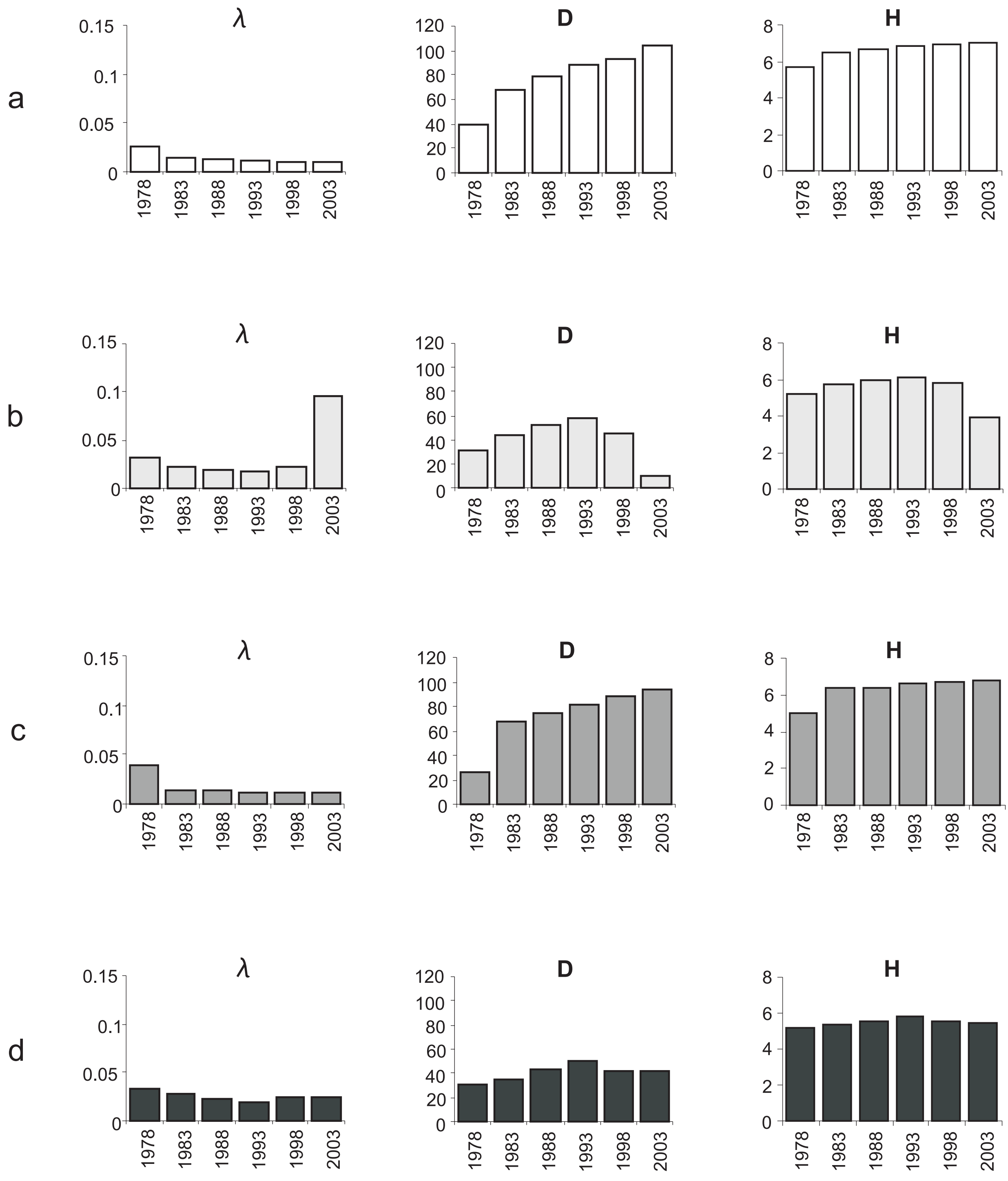

Fig. 9. Dominance and diversity indices for the flora of the entire study area and for its sectors corresponding to experimental treatments
Explanations: λ – Simpson's dominance index, D – Simpson's diversity index, H – Shannon-Wiener diversity index; experimental treatments: a – entire experimental area, b – no pressure, c – mowing, d – ploughing

transformations, including a very significant enrichment.

- Within 25 years, this area of less than 0.5 ha was colonized by 1/4 of the total species pool of the entire Wielkopolski National Park.
- The greatest species richness was achieved under the mowing regime.
- Flora of the forest clearing underwent a spatial differentiation, i.e. species with similar habitat and phytocoenotic preferences aggregated at sites experiencing similar type and intensity of anthropic pressure.

Our attempt to relate diversity changes to the principal processes of vegetation dynamics demonstrated that certain indices of floristic diversity, as well as their temporal spectra, correspond to specific stages of vegetation succession, regeneration or fluctuation.

References

Balcerkiewicz S. & Pawlak G. 2001. Spontaniczne zarastanie polany śródleśnej i antropogeniczna modyfikacja tego procesu – prezentacja długoterminowego eksperymentu prowadzonego na powierzchni stałej w Wielkopolskim Parku Narodowym. In: M. Wojterska (ed.). Szata roślinna Wielkopolski i Pojezierza Południowopomorskiego. Przewodnik sesji terenowych 52. Zjazdu PTB, pp. 274-288. Bogucki Wyd. Nauk., Poznań.

Balcerkiewicz S. & Sławnikowski O. 1998. PROFIT 3.0. Pakiet programów komputerowych do analiz geobotanicznych. Profit s.c., Poznań.

Braun-Blanquet J. 1964. Pflanzensoziologie. Grundzüge der Vegetationskunde. 3. Aufl. 865 pp. Springer, Wien-New York.

Dierschke H. 1994. Pflanzensoziologie, Grundlagen und Methoden. 683 pp. Verlag E. Ulmer, Stuttgart.

Mirek Z., Piękoś-Mirkowa H., Zając A. & Zając M. 2002. Flowering plants and pteridophytes of Poland. A checklist. In: Z. Mirek (ed.). Biodiversity of Poland 1, 442 pp. W. Szafer Institute of Botany, Polish Academy of Sciences, Kraków.

Weiner J. 1999. Życie i ewolucja biosfery. Podręcznik ekologii ogólnej. 591 pp. Wyd. Nauk. PWN, Warszawa.

Żukowski W., Latowski K., Jackowiak B. & Chmiel J. 1995. Rośliny naczyniowe Wielkopolskiego Parku Narodowego. Prace Zakładu Taksonomii Roślin UAM w Poznaniu 4: 1-229. Bogucki Wyd. Nauk., Poznań.