Changes in the corn-weed communities in the Malopolska Upland (S. Poland) from 1947 to 1988

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Changes in the corn-weed communities in the Małopolska Upland (S. Poland) from 1947 to 1988

Helena TRZCIŃSKA-TACIK

1. INTRODUCTION

The corn-weed communities which have been accompanying the grain-crops in Poland for six thousands years, nowadays undergo great alterations. The changes occur in all of Europe and are connected with the shifting of cultivation measures. General problems and large areas were described by ELLENBERG (1978) and HOLZNER and IMMONEN (1982), regional papers were published from many countries, e.g. Yugoslavia (KOJIC (1978), Austria (HOLZNER and IMMONEN 1982), Czechoslovakia (KROPAC 1984), Sweden (SVENSSON and WIGREN 1982, 1985a,b), Great Britain (FRYER and CHANCELLOR 1970, PERRING 1974), Germany (HILBIG 1982, 1987, HILBIG and JAGE 1984, KOCK 1984, OTTO 1981, SCHUBERT 1986, WAGENITZ and MEYER 1981) and Soviet Union (TUGANAEV 1970). The changes in Poland were described by e.g. BOROWIEC et al. (1974), KORNAS (1987), SZOTKOWSKI (1989), WARCHOLINSKA (1979), WNUK (1989), WOJCIK and KMOSEK (1988). Segetal communities are changing with increasing tendency.

This paper deals with the contemporary changes in the two main corn-weed communities (*Vicietum tetraspermae* and *Caucalido-Scandicetum*) in the southern part of the Malopolska Upland. Since the reference material in the first paper describing corn-weed communities in Poland originated from this region (KORNAS 1950), it was especially beneficial to carry out the studies here.

2. AREA OF INVESTIGATION, MATERIAL AND METHODS

The investigation area is situated in the southern part of the Malopolska Upland (200-500 m a.s.l.) (Fig. 1). Field plots (0.5-5 ha) within small or medium farms were investigated. Data were collected by means of the phytosociological relevés (after Braun-Blanquet) in localities or regions with typically developed communities (Tables 1-4). The relevés were done in 1986-1988 in the same or neighbouring stands as in 1947-1948 (KORNAS 1950), 1954 (MEDWECKA-KORNAS 1959), 1964, 1972-1975.

The relevés were listed in phytosociological tables and constancy degrees were calculated. They are presented in synthetic tables (Tables 3 and 4). In order to show the two types of changes in the corn-weed communities representative relevés were chosen, sums of mean cover values for all characteristic species of syntaxonomical or systematical group distinguished were calculated in each relevé and displayed on diagrams (Figs. 5 and 6). The syntaxo-

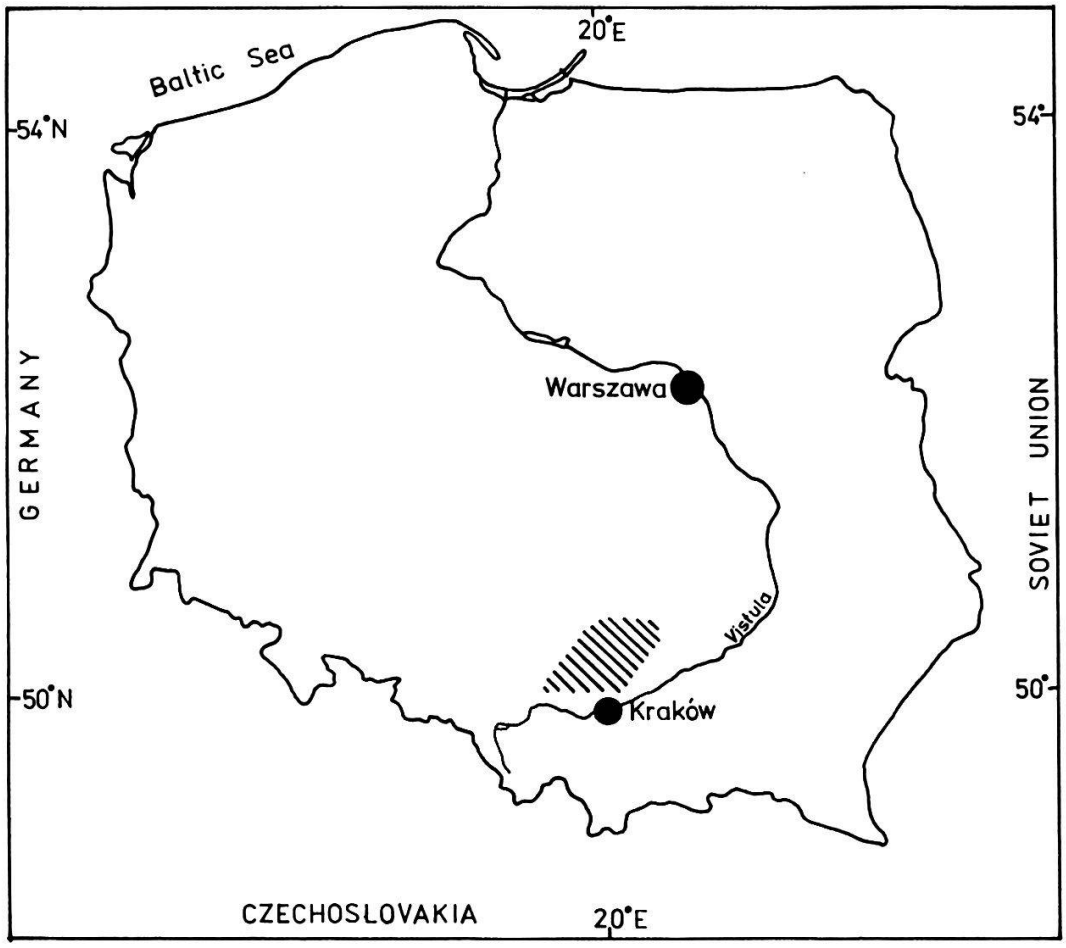

Fig. 1. Investigation area (shaded).

nomical system and nomenclature follows MEDWECKA-KORNAS et al. (1972), the taxonomical nomenclature follows HESS et al. (1984).

3. RESULTS

Increase in cover of cultivated plants (Tables 1 and 2, Fig. 2)
The increase in cover of cultivated plants is most striking in the *Caucalido-Scandicetum* association, especially as comparing 1947-1948 vs. 1972-1975. In the next years the average values of the cultivated plant cover increased also in the *Vicietum tetraspermae* association, but in a lesser extent. This was brought about by their initial high cover and the domination of the ecological niche of the community by cultivated plants. The increasing amplitude between the extreme values from 1986-1988 and the decreasing percentage of fields with *Secale cereale* in the *Vicietum tetraspermae* association from 85% (in 1947-1948) to 67% (in 1964), and to 40% (in 1986-1988) should be stressed (Table 1).
Changes in the weed cover (Tables 1 and 2, Fig. 3)
The decreasing of the cover of weeds is clearly visible when data from 1947-1948, 1954, and 1964 are compared with those from 1986-1988. However, the differences between 1972-1975 and 1986-1988 are not so striking. The main decrease in the cover of weeds was noted in 1960-1970. From 1947-1948 the cover of weeds was higher than the cover of cereals, in 1954 these values were equal, and in 1964 the cover of cereals was the highest. From 1972-1975 the domination of cereals was most stable and the amplitudes of the weed cover values were lowest. In 1986-1988 the amplitudes of the weed cover values were largest. This denotes that besides the "pure" fields there were also fields dominated by weeds. It is interesting that the slopes of curves describing the decrease-process of the weed cover are almost parallel, which means that the decreasing rate of cover was the same in different regions.
Decrease in species numbers in the relevés (Tables 1 and 2, Fig. 4)
The diminishing number of species (mean and extreme values) is clearly visible in both associations. Data from 1947-1948, 1954, 1964, and 1972-1975 do not vary one from another while they deviate from those of 1986-1988. This confirms the high intensity of species withdrawal in 1975-1988. The parallel course of the species diminishing curves (especially striking in *Vicietum tetraspermae* association, Fig. 3b) denote that the rate of species withdrawal is independent of the floristic richness in a given area.

Table 1. Cover of cultivated plants and weeds, number of species in relevés, soil reaction and number of occurrences of characteristic species in one relevé of *Caucalido-Scandicetum* in 1947-1948 vs. 1986-1988.

* after KORNAS (1950)
** after MEDWECKA-KORNAS (1959)
*** the same as in Table 3
1 Localities: Uniejow-Redziny, Pstroszyce, Pstroszyce-Widnica, Strzezow Dziadowski
2 Localities: Czaple Male, Pojalowice, Klucze, Dluzec, Luczyce, Pychowice
a two relevés from 1948 (KORNAS 1950), and thirteen from 1972-1975
b cover of corn and *Trifolium repens* or *T. pratense*

No. of column***	1	2	3	4	5	6	7	8
Region or locality	Miechow Upland[1]		Moczydlo near Ksiaz Wielki		Skorocice near Busko		Fragments[2]	
Period of time	1947-1948*	1988	1972-1973	1986-1988	1954**	1987	(1948[a]) 1972-1975	1986-1988
No. of relevés	10	10	10	10	3	5	15 (2)[a]+13	15
No. of relevés with cultivated plants:								
Avena sativa	1	1	2	-	-	-	4(-)[a]	2
Hordeum vulgare	1	1	1	2	-	1	4(-)[a]	3
Secale cereale	1	3	2	2	1	1	4(-)[a]	1
Triticum vulgare	7	5	4	6	2	3	3(2)[a]	9
Brassica napus	-	-	1	-	-	-	-(-)[a]	-
Cover of cultivated plants (%):								
Mean	42	91	84	90	56	95	92(25)[a]	91
Range	20-70	70-138[b]	70-98	40-120[b]	40-70	93-100	70-130 (20-30)[a]	70-100
Cover of weeds (%):								
Mean	63	36	49	42	56	29	47(79)[a]	42
Range	30-90	15-70	30-60	20-95	40-70	15-40	25-80 (60-98)[a]	10-70
Number of species in relevés:								
Mean	48	43	49	38	51	39	42(50)[a]	39
Range	41-58	30-56	37-65	30-44	36-59	28-49	33-50 (48-53)[a]	28-47
Soil reaction in 0-5 cm layer:								
Mean	-	7.3	7.3	7.2	-	7.0	6.3	6.8
Range	-	7.0-7.5	7.0-8.0	7.0-7.5	-	6.8-7.0	5.0-7.0	6.5-7.0

Table 1 (continued)

No. of column***	1	2	3	4	5	6	7	8
No. of occurences of characteristic species in relevé of *Caucalido-Scandicetum*:								
Mean	4.4	0.7	2.9	1.1	4.7	1.6	0.1	0.1
Range	3-6	0-2	1-5	0-2	1-7	1-3	0-1	0-1
Caucalidion:								
Mean	5.6	5.7	7.8	6.7	6.7	5.6	3.7	4.2
Range	4-8	4-8	6-10	5-9	4-8	3-9	1-7	1-7

Table 2. Cover of cultivated plants and weeds, number of species in relevés, and soil reaction in *Vicietum tetraspermae* in 1947-1948 vs. 1986-1988.

* after KORNAS (1950)

** after MEDWECKA-KORNAS and KORNAS (1963)

*** the same as in Table 4

1 Localities: Murownia, Beblo, Pieskowa Skala, Mlynik, Wola Kalinowska, vicinity of Bukowki, Grodzisko Ojcowskie, Ojcow Stary, Ojcow Stary (small valley)

a cover of corn and *Trifolium repens* or *T. pratense*

No. of column***	1	2	3	4	5	6	7	8
Region or locality	Cracow Jura	Vicinity of Ojcow			Zadroze		Kozlow	
Period of time	1947-1948*	1963**	1964[1]	1986-1987[1]	1972-1973	1986-1987	1972	1987
No. of relevés	30	10	15	15	10	10	5	5
No. of relevés with cultivated plants:								
Avena sativa	-	-	3	-	2	-	1	1
Hordeum vulgare	-	-	-	-	2	2	1	2
Secale cereale	25	-	10	6	4	3	2	1
Triticum vulgare	5	-	2	9	2	5	1	1
Cover of cultivated plants (%):								
Mean	59	-	91	97	84	103	95	96
Range	20-90	-	65-115	70-138	80-130	80-160[a]	76-135[a]	83-110[a]
Cover of weeds (%):								
Mean	66	-	62	44	48	48	36	39
Range	20-98	-	40-85	15-90	40-70	20-70	24-45	20-70
Number of species in relevés:								
Mean	49	-	51	42	49	44	45	39
Range	36-61	-	38-63	27-49	44-57	32-53	40-49	31-46
Soil reaction in 0-5 cm layer:								
Mean	-	-	5.6	6.3	5.9	6.0	5.6	5.3
Range	-	-	5.0-7.0	5.5-7.0	5.0-7.0	5.8-6.3	5.0-6.0	5.0-6.0

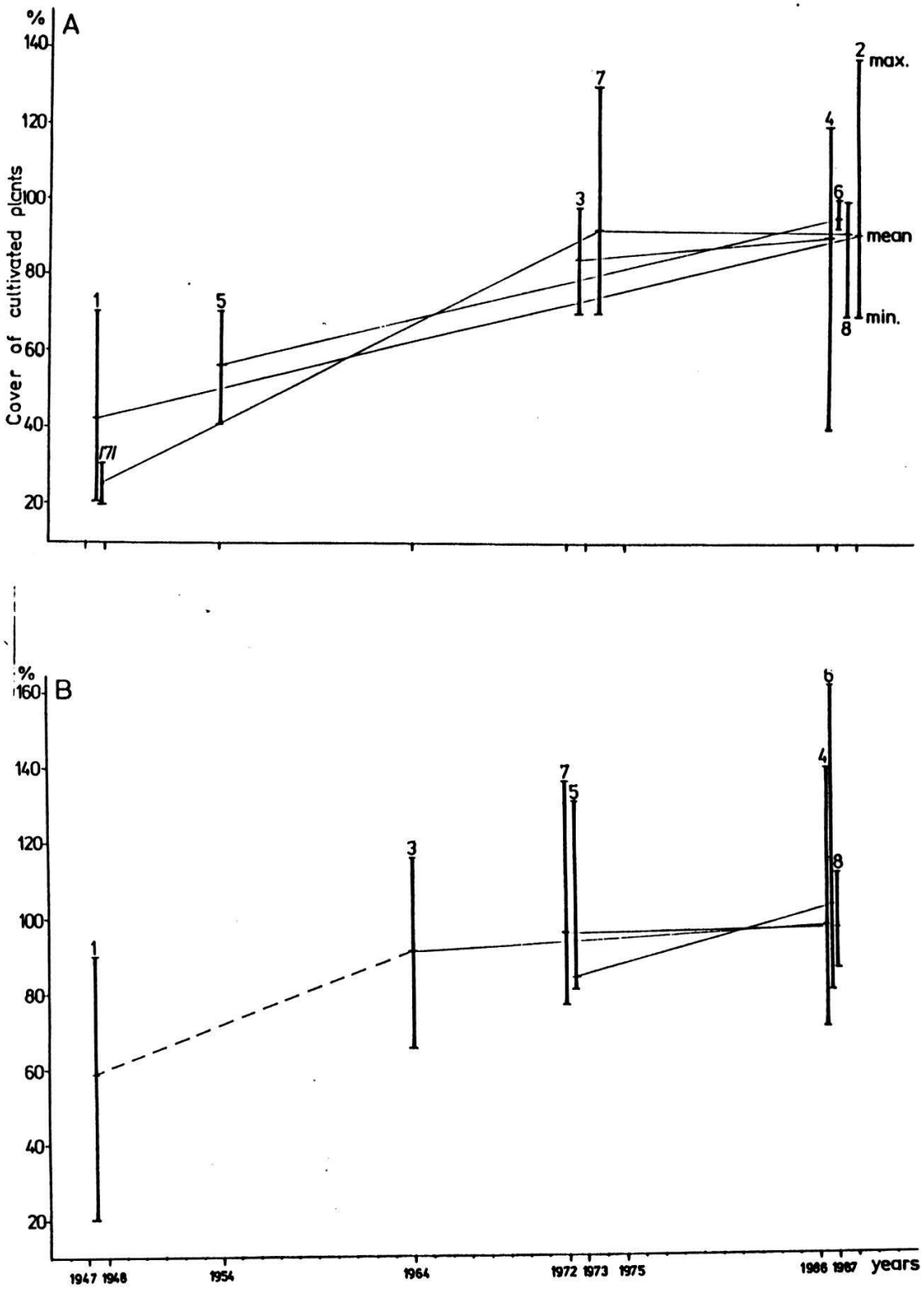

Fig. 2. The cover of cultivated plants in 1947-1988.
A - *Caucalido-Scandicetum*, B - *Vicietum tetraspermae*.
Numbers correspond to columns in Tables 1-4.
—— average values from the same localities or regions
- - - - average values from the region bigger and smaller, lying in its border
The vertical lines denote the difference between the maximum and minimum cover

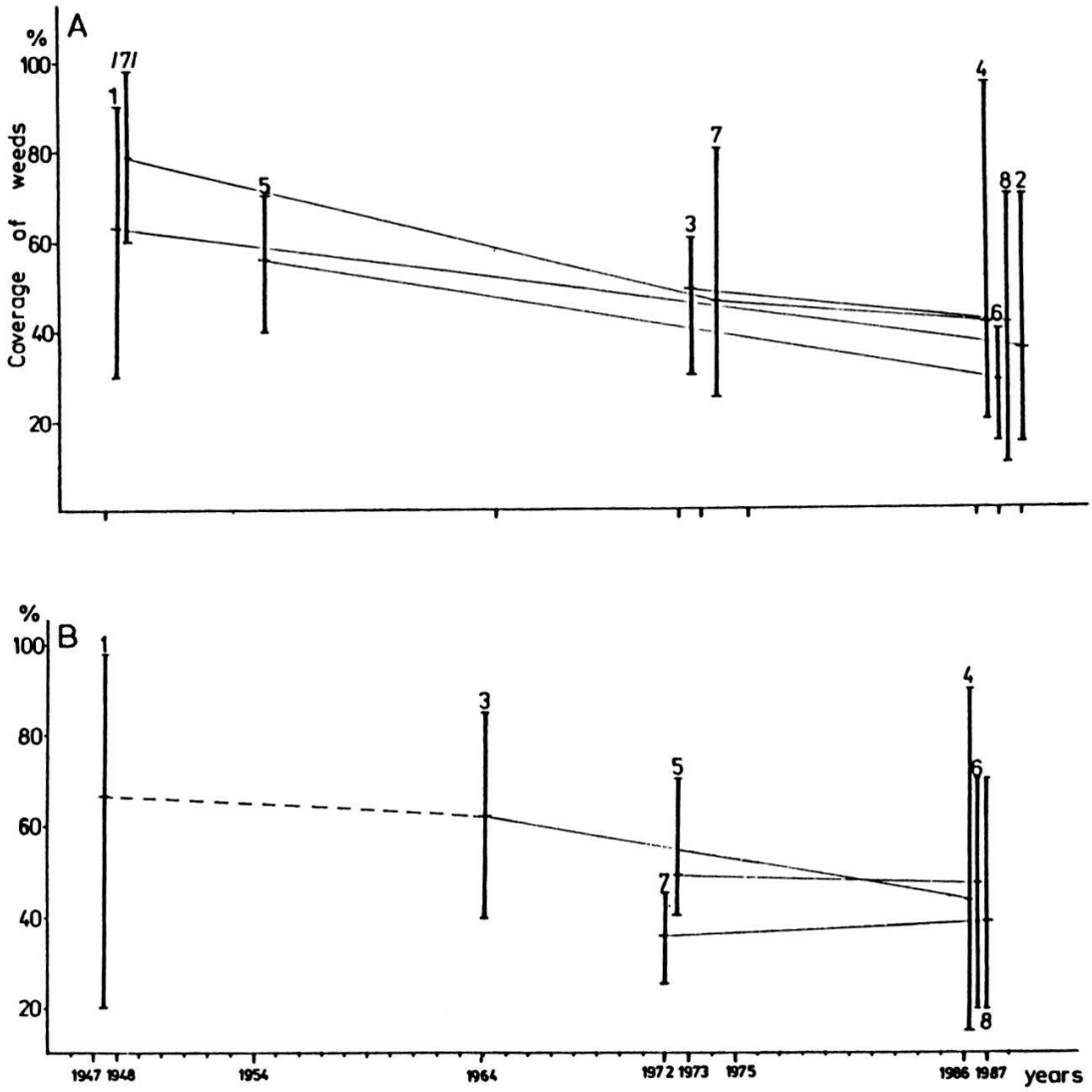

Fig. 3. The cover of weeds 1947-1988.
A - *Caucalido-Scandicetum*, B - *Vicietum tetraspermae*.
Numbers correspond to columns in Tables 1-4.
—— average values from the same localities or regions
- - - - average values from the region bigger and smaller, lying in its border
The vertical lines denote the difference between the maximum and minimum cover

Withdrawal of species (Tables 3 and 4)

Withdrawing speirochores were found in both associations: *Agrostemma githago*, *Rhinanthus glaber*, *Galium spurium* and *Centaurea cyanus* (a facultative speirochoric species); *Bromus secalinus* belongs to the *Vicietum tetraspermae* association, *Caucalis daucoides* and *Ranunculus arvensis* belong to the *Caucalido-Scandicetum* association. Small heliophilous species (e.g. *Linaria minor*) or competitively weak species (e.g. *Anagallis arvensis*) and species characteristic of *Centauretalia cyani* order (i.e. *Anthemis arvensis*,

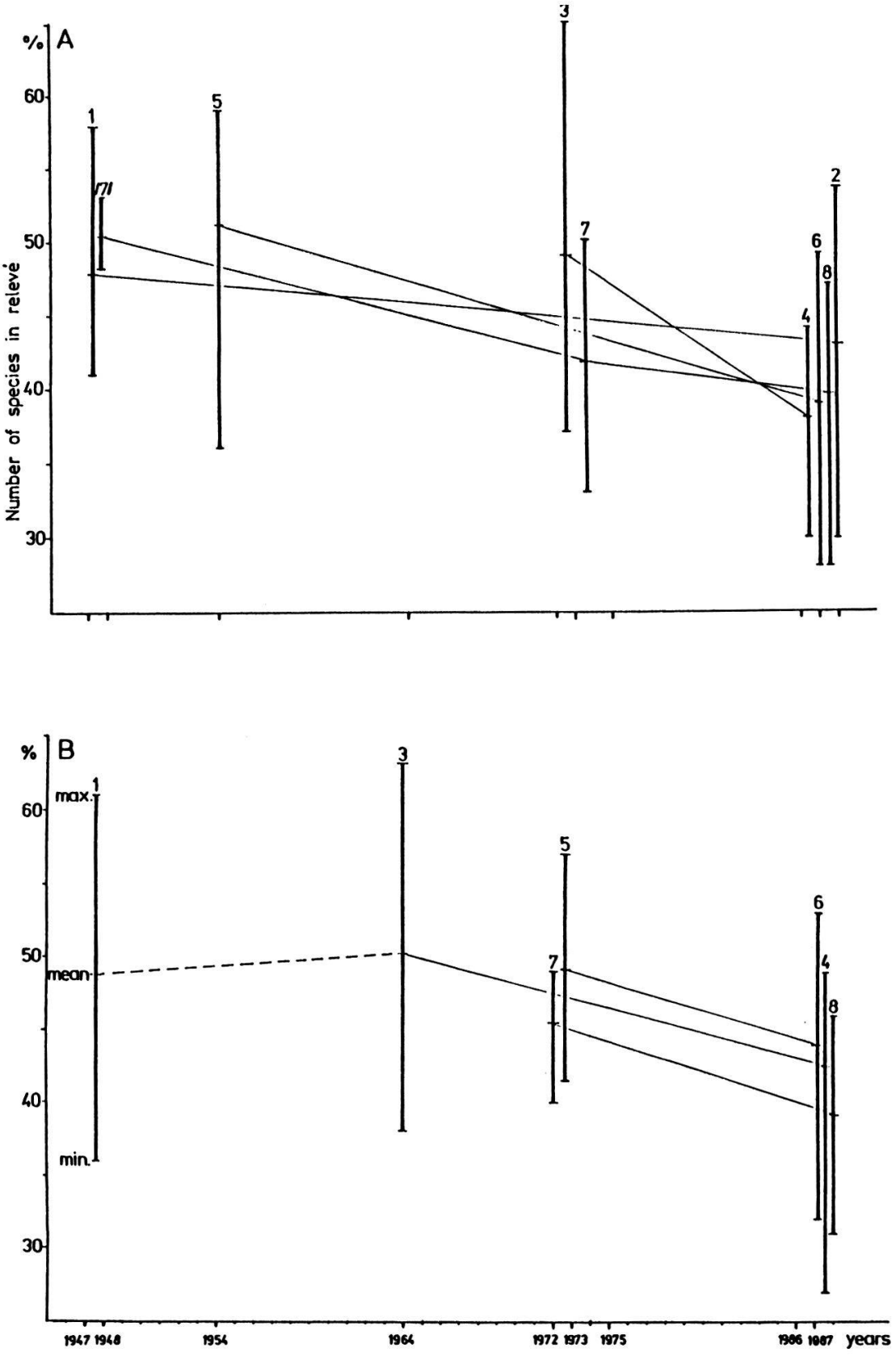

Fig. 4. The number of species in relevés in 1947-1988. Explanations as in Fig. 3.

Camelina sylvestris and *Lithospermum arvense*) withdraw in both associations. In the *Caucalido-Scandicetum* association, the rare species characteristic of this association (*Allium rotundum* and *Bupleurum rotundifolium*), as well as previously abundant species (*Caucalis daucoides* or *Scandix pecten-veneris*), are almost totally extinct. Species previously abundant nowadays become rare (e.g. *Adonis aestivalis* or *Stachys annua*). Species of xerothermic grasslands withdraw, too (e.g. *Alyssum calycinum*, *Acinos arvensis*, *Euphorbia cyparissias*, *Poa compressa* and *Ranunculus bulbosus*). In stands of the *Vicietum tetraspermae* association, previously frequent acidophilous species have become rare (e.g. *Anthemis arvensis*, *Raphanus raphanistrum*, *Rumex acetosella*, *Scleranthus annuus*, and *Spergula arvensis*). To the withdrawing species there may also be included species of wet furrows belonging to the *Isoëto-Nanojuncetea* class (*Anagallis minima*, *Gnaphalium uliginosum*, *Gypsophila muralis* and *Spergularia rubra*). The process of withdrawal is sometimes restricted to one locality or region (e.g. *Rumex acetosella* withdraws in the surroundings of Ojcow and in Zadroze but persists in Kozlow). Sometimes a species withdraws in a given site, e.g. *Centaurea cyanus* declines in the *Caucalido-Scandicetum* association, but persists in the *Vicietum tetraspermae* association. It seems that a given species dies out faster the further the habitat is from its optimum; for *Centaurea cyanus* the shallow cretaceous rendzina is too dry and too alkaline.

Spreading of species (Tables 3 and 4, Figs. 5 and 6)

The process of species spreading (measured by constancy and/or cover degrees) concerns three groups of species: *Gramineae*, nitrophilous species, and certain characteristic species of *Caucalidion* alliance.

Three species of grasses considerably increased their cover: *Avena fatua* in the fields of former *Caucalido-Scandicetum* association (Fig. 5) and in the community of the *Caucalidion* alliance; *Apera spica-venti* and/or *Agropyron repens* in the fields of *Vicietum tetraspermae* association (Fig. 6). These three species may occur abundantly (50-75% or 75-100% cover) and predominantly in grain-crops with short flowering stems. The ecological success of the grasses is brought about by their timing of phenological events and ecological behaviour: For *Apera spica-venti* and *Avena fatua* it is the non-simultaneous ripening and shedding of seeds, which may partly germinate in autumn and then winter as vegetative specimens. In spring they grow and come into ear quicker than cereal, producing a layer which shades the cultivated plants; it gives them a predominating position in competition. *Agropyron repens* has numerous rhizomes enabling it to propagate especially while

Table 3. Constancy degrees and abundance degrees in *Caucalido-Scandicetum* in 1947-1948 vs. 1986-1988. (For explanations see Table 1).

No. of column	1	2	3	4	5	6	7	8
Region or locality	Miechow Upland[1]		Moczydlo near Ksiaz Wielki		Skorocice near Busko		Fragments[2]	
Type of soil	Cretaceous rendzina				Gypsum rendzina		Jurassic rendzina or brown soil rich in calcium carbonate	
Period of time	1947-1948*	1988	1972-1975	1986-1988	1954 **	1987	(1948[a]) 1972-1975	1986-1988
Ch. Caucalido-Scandicetum:								
Adonis aestivalis	V^{+-2}	I^{+}	V^{+-2}	IV^{+-1}	III^{+-2}	IV^{+}	-	I^{+}
Stachys annua	V^{+-2}	III^{+-1}	-	-	II^{+}	III^{+-2}	-	-
Fumaria vaillanti	IV^{+-2}	-	-	I^{+-1}	I^{+}	-	I^{+}	-
Caucalis platycarpos	III^{+-2}	-	II^{+}	-	II^{2}	-	-	-
Scandix pecten-veneris	III^{+-2}	-	II^{+}	-	-	-	-	-
Conringia orientalis	II^{r-+}	I^{r}	I^{1}	-	II^{+}	-	-	-
Allium rotundum	I^{1}	-	I^{+}	-	-	-	-	-
Galium tricornutum	I^{+}	-	-	-	-	-	-	-
Thymelea passerina	I^{+}	-	-	-	-	-	-	-
Adonis flammea	-	-	-	-	I^{+}	-	-	-
Anagallis coerulea	-	-	IV^{+-1}	I^{+}	I^{1}	-	-	-
Bupleurum rotundifolium	-	-	II^{+}	I^{r}	-	-	-	-
Euphorbia falcata	-	-	-	-	II^{+}	I^{+}	-	-
Ch. Caucalidion:								
Delphinium consolida	V^{1-2}	V^{+-2}	V^{+-2}	V^{+-2}	III	IV^{+-2}	IV^{+-2}	IV^{+-2}
Euphorbia exigua	V^{+-2}	III^{+-2}	V^{+-1}	IV^{+-1}	II^{+-1}	II^{+}	II^{+-1}	I^{+-1}
Melampyrum arvense	V^{+-3}	IV^{+-2}	V^{+-2}	IV^{+-1}	II^{+}	I^{+}	I2	I^{+-1}
Valerianella dentata	V^{+-2}	III^{+-2}	IV^{+-1}	II^{+-1}	I^{+}	II^{+}	II^{+-1}	III^{+-1}
Avena fatua	IV^{+-1}	IV^{+-4}	V^{+-3}	V^{+-5}	II^{+}	V^{+-2}	II^{+-3}	V^{+-4}
Neslia paniculata	IV^{+-1}	II^{+}	IV^{+-2}	IV+	III^{+-1}	III^{+-2}	III^{+-1}	III^{+-1}
Ranunculus arvensis	III^{+-2}	I^{+-1}	II^{+-1}	-	II^{+-1}	-	-	-
Silene noctiflora	II^{+-1}	III^{+}	IV^{+-1}	V^{+-2}	III^{+}	V^{+-2}	II^{+-1}	III^{+-1}
Sherardia arvensis	II^{+-2}	III^{+-3}	-	-	-	-	II^{+-2}	II^{+-3}
Aethusa cynapium	I^{+}	III^{+-2}	V^{+-2}	V^{1-2}	-	II^{+-2}	II^{+-2}	II^{1}
Lathyrus tuberosus	-	-	II^{+-1}	II^{+-1}	II^{+-1}	IV^{1-2}	I^{+}	I^{+}
Lolium temulentum	-	-	-	-	-	-	I^{+}	-
Nigella arvensis	-	-	-	-	-	-	I^{+}	-
Valerianella rimosa	-	-	-	-	-	-	I^{+}	-
Ch. Centauretalia cyani (Ap = *Ch.Aperion*):								
Centaurea cyanus	V^{+-3}	III^{r-+}	V^{+-1}	IV^{+-1}	II^{+-2}	V^{+}	V^{+-2}	IV^{+-1}
Papaver rhoeas	V^{+-2}	V^{+-1}	V^{+-2}	V^{+-2}	III^{+-2}	IV^{+-3}	IV^{+-2}	V^{+-1}

Table 3 (continued)

No. of column	1	2	3	4	5	6	7	8
Agrostemma githago	IV^{r-1}	II^{+}	III^{+}	-	III^{+-1}	-	II^{+-2}	I^{1}
Camelina sylvestris	IV^{+-1}	I^{1}	I^{+}	II^{+-1}	III^{+}	IV^{+-1}	I^{+}	I^{+}
Galium spurium	IV^{+-1}	III^{+-2}	IV^{+-1}	V^{+-1}	III^{+-1}	I^{+}	II^{+}	I^{+}
Anthemis arvensis	III^{+-2}	-	-	-	-	-	III^{+-2}	II^{+-2}
Lithospermum arvense	III^{+-1}	II^{+}	V^{+-2}	III^{+-1}	III^{+}	IV^{+-2}	III^{+-1}	III^{+-1}
Odontities verna ssp. *verna*	III^{+-3}	I^{1}	III^{+}	I^{+}	III^{+-2}	-	I^{+}	-
Vicia sativa	III^{+}	I^{+}	-	-	-	-	I^{+}	-
Rhinanthus glaber	II^{+}	II^{+-1}	I^{+}	-	III^{+}	II^{+}	I^{+}	I^{+}
Apera spica-venti (Ap)	II^{+-2}	IV^{+-1}	-	II^{r-+}	II^{+}	IV^{+-1}	IV^{+-2}	IV^{+-4}
Vicia angustifolia	II^{+-1}	III^{+}	II^{+}	I^{+}	III^{+-1}	II^{+-1}	III^{+-1}	I^{+-3}
V. hirsuta (Ap)	II^{r-+}	-	-	-	II^{+-2}	-	II^{+-1}	I^{+-2}
Bromus secalinus (Ap)	-	-	-	-	II^{+}	-	I^{+}	I^{+}
Vicia tetrasperma (Ap)	-	-	I^{+}	-	-	-	II^{+}	I^{+}
V. villosa (Ap)	-	-	-	-	-	-	I^{+}	I^{+}
Ch. Secali-Violetalia arvensis(PCh=*Polygono-Chenopodietalia*):								
Anagallis arvensis	V^{+-2}	II^{+-1}	V^{+-1}	II^{+}	II^{+-1}	II^{+}	IV^{+-2}	III^{+}
Polygonum convonvulus	V^{+-3}	V^{+-2}	V^{+-1}	IV^{+-2}	III$^{1-2}$	V^{+-1}	V^{+-2}	V^{+-2}
Sinapis arvensis	V^{+-2}	IV^{+-1}	V^{+-2}	IV^{+-3}	II$^{2-3}$	V^{+-1}	V^{+-2}	IV^{+-2}
Linaria minor	IV^{+-2}	II^{+}	-	-	-	-	I^{+}	I^{+}
Sonchus asper (PCh)	IV^{+-2}	II^{+}	II^{+-1}	II^{+}	-	-	III^{+-1}	II^{+}
Veronica polita (PCh)	IV^{+-2}	IV^{+}	III^{+}	I^{+}	-	-	I^{+-2}	III^{+}
Viola arvensis	IV^{+-2}	I^{+}	V^{+-1}	V^{+-1}	III^{+-1}	III^{+-1}	IV^{+-2}	IV^{+-1}
Lamium amplexicaule (PCh)	III^{+}	I^{+}	I^{+}	II^{+}	-	-	I^{+}	-
Lapsana communis spp. *communis*	II^{+}	I^{+}	V^{+-1}	V^{+}	-	-	I^{+}	II^{+-1}
Sonchus arvensis	II^{+}	IV^{+-1}	III^{+-1}	III^{+-2}	II^{+-2}	II^{+-1}	V^{+-2}	IV^{+-3}
Veronica persica (PCh)	II^{+-1}	V^{+-1}	II^{+}	I^{+}	-	I^{+}	I^{+}	II^{+-1}
Euphorbia helioscopia (PCh)	I^{+}	III^{+-1}	III^{+-1}	III^{+-1}	II^{+}	II^{+}	IV^{+-1}	II^{+}
Mentha arvensis	I^{+}	II^{+-1}	-	-	II^{+-2}	III^{+-2}	III^{+-1}	III^{+-2}
Myosotis arvensis	I^{+}	III^{+-2}	V^{+}	III^{+}	-	I^{+}	IV^{+}	IV^{+-1}
Stachys palustris	I^{+}	I^{+}	I^{+}	-	I^{1}	II^{+-1}	II^{+-1}	III^{+-1}
Veronica arvensis	I^{+}	-	-	-	-	-	I^{+}	II^{+}
Tripleurospermum inodorum	-	II^{+-1}	II^{+}	II^{+}	-	IV^{+-1}	II^{+-1}	III^{+-2}
Polygonum lapatifolium ssp. *incanum* (incl. fo. *incanum*)	-	-	-	-	-	I^{+}	IV^{+-3}	III^{+-1}
Galinsoga parviflora	-	-	-	-	-	-	I^{+}	II^{+}
Ch. Rudero-Secalietea:								
Chenopodium album	V^{+-2}	I^{+}	III^{+}	IV^{+-2}	II^{+}	V^{+-2}	V^{+-3}	V^{+-1}
Convonvulus arvensis	V^{+-3}	V^{+-2}	V^{+-3}	V$^{1-2}$	III$^{2-3}$	V^{+-3}	V$^{1-4}$	IV$^{1-2}$
Polygonum aviculare	III^{+-2}	III^{+-1}	IV^{+-1}	III^{+-1}	III^{+-1}	IV^{+-1}	V^{+-2}	V^{+-1}
Agropyron repens	II^{+-1}	V^{+-2}	V^{+-3}	V^{+-2}	II^{+}	V^{+-2}	IV$^{1-2}$	V^{+-3}
Cirsium arvense	II^{+-1}	IV^{+-1}	V^{+-2}	III^{+-2}	III^{+}	V^{+}	V^{+-2}	V^{+-2}

Table 3 (continued)

No. of column	1	2	3	4	5	6	7	8
Rumex crispus	II^{+}	I^{+}	III^{+-1}	II^{+}	-	-	III^{+}	I^{+}
Galeopsis bifida	I^{+}	I^{+}	I^{+}	IV^{+}	-	I^{+}	III^{+-2}	III^{+-2}
Stellaria media	I^{+}	V^{+-2}	V^{+-3}	IV^{+-1}	-	IV^{+-1}	V^{+-3}	IV^{+-3}
Artemisia vulgaris	-	II^{+}	I^{+}	-	-	-	-	-
Carduus acanthoides	-	II^{+}	-	-	-	-	-	-
Geranium pusillum	I^{+}	I^{+}	I^{+}	III^{+-1}	I^{+}	-	II^{+}	III^{+}
Galeopsis pubescens	-	I^{+}	I^{+}	II^{+}	-	I^{+}	-	-
G. tetrahit	-	-	-	II^{+}	-	-	I^{1}	I^{+}
Descurainia sophia	-	-	-	I^{+}	II^{+}	IV^{+}	-	-
Equisetum arvense	-	-	I^{+}	I^{+}	-	-	II^{+-1}	II^{+}
Capsella bursa-pastoris	-	-	-	-	-	-	I^{+}	II^{+}
Silene alba	-	I^{+}	I^{+}	I^{+}	-	-	III^{+-1}	I^{+}
Others:								
Daucus carota	V^{+-2}	V^{+-1}	III^{+-2}	I^{+}	I^{+}	-	I^{1}	II^{+-1}
Allium cf. *vineale*	IV^{+}	-	-	-	-	-	-	-
Campanula rapunculoides	IV^{+-3}	V^{+-3}	V$^{1-2}$	V^{+-1}	I^{2}	III^{+-2}	III^{+-1}	II^{+-2}
Galium aparine	IV^{+-2}	IV^{+-2}	IV^{+-3}	V^{+-3}	-	III^{+-2}	V^{+-2}	V^{+-2}
Medicago lupulina	IV^{+-2}	III^{+-1}	V^{+}	II^{+}	III^{+}	III^{+}	III^{+}	II^{+}
Ranunculus bulbosus	IV^{+}	-	-	-	-	-	-	-
Alyssum calycinum	III^{+-1}	-	-	-	-	-	-	-
Arenaria serpyllifolia	III^{+-3}	III^{+-1}	III^{+}	III^{+}	I^{1}	I^{+}	III^{+-3}	III^{+}
Acinos arvensis	III^{+-2}	-	-	-	-	-	-	-
Euphorbia cyparissias	III^{+-2}	I^{+}	I^{+}	-	I^{+}	II^{+}	I^{+}	I^{+}
Galeopsis ladanum	III^{+}	-	-	-	-	-	-	-
Poa compressa	III^{+}	I^{+-1}	II^{+-1}	I^{+}	II^{+}	I^{+}	I^{+}	I^{+}
Salvia verticillata	III^{+-1}	III^{+-1}	-	I^{+-1}	-	-	II^{+-1}	II^{+}
Cerastium arvense	II^{+}	-	-	-	-	-	-	-
Coronilla varia	II^{+-1}	II^{+}	II^{+}	-	II^{+}	III^{+}	II^{+}	I^{+}
Euphorbia esula	II^{+}	II^{+}	IV^{+-1}	IV^{+-1}	III^{+}	II^{+}	II^{+-1}	III^{+-1}
Falcaria vulgaris	II^{+-1}	III^{+}	V^{+-2}	V^{+-1}	I^{+}	V^{+}	I^{+}	I^{+}
Knautia arvensis	II^{+-2}	I^{+}	III^{+-1}	III^{+}	II^{+}	II^{+}	III^{+}	II^{+}
Taraxacum officinale	II^{+}	IV^{+-1}	V^{+-2}	II^{+}	-	I^{+}	IV^{+-1}	III^{+-1}
Centaurea scabiosa	I^{+}	II^{+}	IV^{+}	II^{+}	II^{+-1}	I^{+}	I^{+-1}	I^{+-1}
Ranunculus repens	I^{+}	III^{+-3}	I^{+}	-	-	I^{+}	II^{+-1}	II^{+-1}
Tussilago farfara	I^{+}	II$^{1-2}$	I^{+}	I^{+}	II^{+}	III^{+}	I^{+-2}	I^{+-1}
Vicia cracca	I^{+}	II^{+}	II^{+}	I^{+}	II^{+}	III^{+}	II^{+}	II^{+}
Achillea millefolium	-	IV^{+-1}	V^{+-1}	III^{+}	I^{+}	-	III^{+-2}	III^{+-1}
Agrostis gigantea	-	III^{+-3}	III^{+-1}	I$^{1-2}$	I^{+}	I^{+}	IV^{+-3}	IV^{+-3}
Lolium perenne	-	III^{+}	III^{+}	I^{+}	-	-	II^{+}	III^{+}
Cichorium intybus	-	III^{+-2}	II^{+}	-	-	-	I^{+}	I^{+}
Allium oleraceum	-	II^{+}	II^{+-1}	I^{+}	-	I^{+}	-	I^{+}
Dactylis glomerata	-	II^{+}	-	-	-	-	-	-
Glechoma hederacea	-	II^{+}	-	-	-	-	II^{+}	I^{+}
Rubus caesius	-	-	-	I^{+}	I^{1}	III^{+-1}	-	I^{+}
Odontites serotina	-	-	II^{+}	II^{+-1}	-	I^{+}	-	II^{+-1}
Sanguisorba minor	I^{+}	I^{+}	III^{+-1}	-	-	-	-	-
Plantago intermedia	I^{+}	-	I^{+}	-	-	-	I^{+-1}	II^{+-1}

Table 4. Comparison of constancy degrees and abundance degrees in *Vicietum tetraspermae* in 1947-1948 vs. 1986-1988. (Explanations see in Table 2).

No. of column	1	2	3	4	5	6	7	8
Region or locality	Cracow Jura	Vicinity of Ojcow			Zadroze		Kozlow	
Type of soil	Brown or podsolised soils on loess and brown mud							
Period of time	1947-1948*	1963 **	1964[1]	1986-1987[1]	1972-1973	1986-1987	1972	1987
Ch. Vicietum tetraspermae:								
Bromus secalinus	V^{+-2}	IV^{+-2}	V^{+-2}	II^{+-1}	III^{+-2}	I^{+}	III^{+-2}	-
Vicia tetrasperma	IV^{+-2}	III^{+}	III^{+-1}	II^{+-1}	-	-	V^{+-2}	IV^{+-1}
V. villosa	I^{+-4}	-	I^{+}	I^{+-2}	-	-	-	-
Ch. Aperion spica-venti:								
Apera spica-venti	V^{+-2}	IV^{+-2}	V^{+-4}	V$^{1-5}$	V^{+-3}	V$^{1-3}$	V^{+-1}	V^{+-3}
Scleranthus annuus	V^{+-3}	IV^{+-3}	III^{+-2}	I^{+-2}	I^{2}	-	V^{+-2}	III^{+-3}
Vicia angustifolia	V^{+-3}	V^{+-1}	III^{+-1}	I^{+}	II^{+}	III^{+-1}	IV$^{1-2}$	III^{+}
V. hirsuta	V^{+-3}	V^{+-2}	IV^{+-2}	II^{+-2}	I^{+}	II^{+}	IV^{+-1}	IV^{+-1}
Aphanes arvensis	II^{+-1}	-	-	-	-	-	-	-
Ch. Centauretalia cyani:								
Anthemis arvensis	V^{+-3}	IV^{+-2}	II^{+-1}	-	-	-	IV^{+-1}	-
Centaurea cyanus	V^{+-3}	IV^{+-2}	V^{+-1}	IV^{+-2}	V^{+-2}	V^{+-2}	V^{+}	V^{+-2}
Agrostemma githago	IV^{+-2}	III^{+}	II^{+-1}	I^{+-1}	III^{+}	I^{+}	III^{+}	I^{+}
Papaver rhoeas	III^{+-3}	-	I^{+}	III^{+-3}	IV^{+}	III^{+}	-	-
Rhinanthus glaber	II^{+-3}	II^{+}	I^{+}	-	-	-	II^{+-1}	I^{2}
Camelina sylvestris	II^{+}	-	-	-	-	-	-	-
Odontites verna	II^{+-2}	-	II^{+}	I^{+}	-	-	I^{+}	-
Valerianella dentata	II^{+-1}	II^{+-1}	-	-	-	-	-	-
Vicia sativa	I^{+}	-	I^{+-1}	I^{+-1}	I^{+}	-	-	-
Ch. Secali-Violetalia arvensis (PCh. = *Ch. Polygono-Chenopodietalia*):								
Myosotis arvensis	V^{+-2}	V^{+-2}	V^{+-1}	V^{+-2}	V^{+}	V^{+-1}	I^{+}	III^{+}
Polygonum convonvulus	V^{+-2}	V^{+-2}	V^{+-1}	V^{+-1}	V^{+-1}	V^{+-2}	III^{+}	IV^{+}
Sonchus arvensis	V^{+-2}	V$^{1-4}$	V^{+-2}	III^{+-2}	V^{+-1}	V$^{1-2}$	IV^{+-1}	II^{+-1}
Veronica arvensis	V^{+-1}	V^{+-1}	IV^{+}	IV^{+-1}	V^{+-1}	IV^{+-2}	III^{+}	III^{+}
Viola arvensis	V^{+-2}	IV^{+-2}	IV^{+-2}	IV^{+-1}	V^{+-1}	IV^{+-1}	IV^{+-1}	III^{+-2}
Anagallis arvensis	IV^{+-2}	IV^{+-1}	IV^{+-2}	II^{+}	V^{+-2}	II^{+-1}	IV^{+}	-
Mentha arvensis	IV^{+-2}	V^{+-2}	V^{+-3}	IV^{+-3}	V^{+-1}	V^{+-2}	V^{+-1}	III^{+-1}
Myosotis stricta	III^{+-2}	-	-	I^{+-1}	-	I^{+}	III^{+}	II^{+}
Oxalis europaea	III^{+-1}	V^{+-1}	V^{+-2}	III^{+-1}	III^{+}	I^{1}	I^{+}	II^{+}
Stachys palustris	III^{+-1}	V^{+-1}	IV^{+-1}	II^{+-1}	IV^{+-1}	III^{+-1}	III^{+-1}	II^{+-2}
Lapsana communis	II^{+}	IV^{+}	III^{+-2}	III^{+}	V^{+}	V^{+-1}	-	-

Table 4 (continued)

No. of column	1	2	3	4	5	6	7	8
Tripleurospermum inodorum	II^{+-2}	-	III^{+-3}	V^{+-2}	III^{+-2}	V^{+-2}	III^{+-1}	V^{+-3}
Polygonum lapathifolium ssp. *incanum* (incl. fo. *incanum*)	II^{+}	V^{+-2}	IV^{+-2}	III^{+-1}	IV^{+}	II^{+-2}	-	-
Raphanus raphanistrum	II^{+}	III^{+}	I^{+}	-	II^{+-1}	I^{+}	V^{+-1}	IV^{+-2}
Setaria glauca (PCh)	II^{+-2}	II^{+-2}	I^{+}	-	-	-	-	-
Sinapis arvensis	II^{+-2}	III^{+}	IV^{+-1}	III^{+-2}	V^{+-3}	V^{+-1}	-	-
Avena fatua	I^{+}	-	-	I^{+}	-	I^{+}	-	II^{+-1}
Linaria minor	I^{+}	-	-	I^{+}	II^{+}	I^{+}	-	-
Matricaria chamomilla	I^{+}	-	I^{+}	II^{+}	-	-	II^{+}	I^{+}
Euphorbia helioscopia (PCh)	I^{+}	-	II^{+}	I^{+}	I^{+}	II^{+}	-	-
Sonchus asper (PCh)	I^{+-1}	IV^{+}	IV^{+-1}	II^{+-1}	IV^{+-1}	III^{+}	I^{+}	-
Spergula arvensis	I^{+}	III^{+-1}	I^{+}	I^{+-2}	-	-	IV^{+-1}	I^{1}
Veronica persica (PCh)	I^{+}	-	II^{+}	I^{+-1}	III^{+}	II^{+}	-	I^{+}
Galinsoga ciliata (PCh)	-	-	I^{+}	II^{+-3}	-	-	-	-
G. parviflora (PCh)	-	-	I^{+}	I^{+}	-	-	-	II^{+}
Ch. Rudero-Secalietea:								
Agropyron repens	V^{+-3}	V^{+-3}	IV^{+-2}	V^{+-3}	V$^{1-2}$	V^{+-3}	V^{+-3}	V$^{1-2}$
Capsella bursa-pastoris	V^{+-2}	V^{+-1}	IV^{+-1}	IV^{+-2}	V^{+}	IV^{+-1}	II^{+}	I^{+}
Cirsium arvense	V^{+-2}	IV^{+-2}	V^{+-2}	V^{+-2}	V^{+-2}	IV^{+-2}	V^{+-1}	IV^{+-2}
Convonvulus arvensis	V^{+-3}	IV^{+-2}	III^{+-2}	IV^{+-2}	III^{+-2}	IV^{+-2}	III^{+-1}	III^{+-1}
Equisetum arvense	V^{+-3}	IV^{+-3}	IV^{+-2}	III^{+-1}	IV^{+-1}	V^{+-1}	IV^{+}	III^{+-2}
Polygonum aviculare	III^{+-2}	IV^{+-2}	V^{+}	IV^{+-1}	V$^{1-2}$	V^{+-2}	IV^{+}	V^{+-1}
Stellaria media	III^{+-3}	II^{+-1}	III^{+-1}	IV^{+-2}	V^{+-3}	V$^{1-3}$	I^{+}	V$^{1-4}$
Chenopodium album	II^{+-1}	V^{+-1}	V^{+-2}	III^{+}	V^{+}	V^{+-1}	I^{+}	IV^{+}
Galeopsis bifida	II^{+-1}	IV^{+-1}	II^{+-1}	V^{+-2}	V^{+-2}	V^{+-2}	V^{+-1}	V^{+-2}
Polygonum hydropiper	II^{+-2}	IV^{+-2}	I^{+}	III^{+-1}	I^{+}	II^{+-1}	V^{+-2}	V$^{1-2}$
Potentilla anserina	II^{+-1}	IV^{+-2}	III^{+-1}	IV^{+-1}	IV^{r-1}	IV^{+}	-	I^{+}
Matricaria discoidea	I^{+}	II^{+-2}	II^{+}	I^{+}	III^{+-2}	IV^{+-2}	II^{+}	III^{+-1}
Plantago major	I^{+}	-	I^{+}	II^{+}	III^{r-+}	II^{+}	-	I^{+}
Poa annua	I^{+}	-	II^{+-1}	III^{+-2}	IV^{+-3}	III^{+-3}	II^{+-1}	III^{+-1}
Polygonum persicaria (incl. fo. *agreste*)	I^{+}	V^{+-1}	IV^{+-1}	IV^{+-1}	V$^{1-2}$	V^{+-1}	V^{+-1}	IV^{+-1}
Rumex crispus	I^{+}	II^{+}	II^{+}	III^{+}	III^{+}	II^{+}	I^{+}	II^{+}
Galeopsis tetrahit	-	IV^{+}	II^{+-2}	III^{+-1}	III^{+-1}	IV^{+}	-	-
Silene alba	-	-	I^{+}	I^{+}	II^{+}	I^{+}	-	-
Rumex obtusifolius	-	-	I^{+-1}	III^{+}	-	I^{+}	I^{+}	-
Polygonum minus	-	III^{+}	-	-	-	-	-	-
Ch. Isoëto-Nanojuncetea:								
Gnaphalium uliginosum	II^{+-2}	V^{+-2}	III^{+-2}	III^{+-2}	IV^{+}	V^{+-2}	V^{+-1}	IV^{+-1}
Juncus bufonius	II^{+}	IV^{+-2}	III^{+}	IV^{+-2}	V^{+-1}	V^{+-1}	V^{+-1}	V^{+-1}
Plantago intermedia	II^{+-3}	V^{+-2}	IV^{+-2}	IV^{+-2}	IV^{+-2}	V^{+-2}	I^{+}	III$^{1-2}$
Sagina procumbens	II^{+-1}	IV^{+-1}	IV^{+-1}	IV^{+-1}	V^{+}	V^{+}	V^{+-1}	IV^{+}
Anagallis minima	I^{+}	-	-	I^{+}	I^{+}	-	III^{+}	-
Gypsophila muralis	I^{+}	III^{+}	I^{+}	I^{+}	-	-	I^{+}	II^{+}
Spergularia rubra	-	-	II^{+-1}	-	-	-	-	-

Table 4 (continued)

No. of column	1	2	3	4	5	6	7	8
Others:								
Achillea millefolium	V+-2	V+	V+-1	IV+-1	V+-2	IV+-1	V+-1	V+-1
Agrostis gigantea	V+-2	V+-3	V+-2	V1-2	V+-2	IV+-3	V+-2	IV+-1
Cerastium caespitosum	V+	V+-1	IV+	III+	IV+-1	II+	II+	III+
Arenaria serpyllifolia	IV+-4	III+-1	III+	I+	IV+	I+	-	-
Medicago lupulina	IV+-1	IV+-1	IV+-1	I+	III+-1	-	-	-
Euphorbia esula	III+-1	II+-1	I+	-	I+	II+-1	-	-
Poa pratensis	III+	II+	II+	-	II+-1	I+	II+	II+
Ranunculus repens	III+-2	V+-2	V+-1	V+-2	IV+-1	IV+-2	IV+	II+
Stellaria graminea	III+-1	IV+-1	III+	II+	III+-1	I+	IV+	II+
Taraxacum officinale	III+-1	II+	IV+	IV+-1	III+-1	IV+-1	I+	II+-1
Trifolium campestre	III+	II+	II+	-	I+	-	III+	-
Campanula rapunculoides	II+-2	-	I+-1	I+	V+-2	V+-1	-	-
Daucus carota	II+-1	II+	-	I+	-	-	-	-
Euphorbia cyparissias	II+	-	-	-	-	-	-	-
Glechoma hederacea	II+	II+	III+	II+-1	I+	I+	-	-
Knautia arvensis	II+	-	-	-	-	-	-	-
Lysimachia vulgaris	II+	V+-2	I+	-	-	-	-	I+
Phleum pratense	II+-2	II+	III+-2	II+	IV+	III+-1	I+	-
Rubus sp.	II+-1	II+	-	-	I+	-	-	-
Rumex acetosella	II+	IV+	I+	I+-2	II+	-	IV+-1	IV+-1
Sedum maximum	II+	-	I+	I+	III+	I+-2	-	-
Vicia cracca	II+-1	III+-1	III+	II+-1	III+	I+-1	-	-
Galium aparine	I+	II+-1	IV+-1	IV+-2	IV+	III+-1	-	II+
Lolium perenne	I+	II+	II+	II+-1	II+-1	III+-1	-	II+-1
Prunella vulgaris	I+	III+	II+	I1	I+	I+	-	-
Veronica serpyllifolia	I+	III+	I+	-	I+	-	I+	-
Poa trivialis	-	I+	IV+-1	III+-1	IV+-3	IV+-2	-	-
Dactylis glomerata	-	-	-	I+	II+	-	-	III+
Hypochaeris radicata	-	-	-	-	-	-	III+	-
Trifolium arvense	-	-	-	-	-	-	III+	-
Rorippa silvestris	-	-	I+	-	-	-	II+	II+
Plantago lanceolata	-	-	I+	-	II+	I+	-	-
Trifolium dubium	-	-	-	-	-	-	II+	-
Holcus mollis	-	-	-	I1	-	-	I+	-

ploughing. The spreading of grasses is also increased by the high rates of mineral fertilizers and herbicides. In certain stands of the *Vicietum tetraspermae* association (Fig. 6), *Agrostis gigantea* and *Holcus mollis* also take a great part, usually on flattened hump and tops, on loess, where pH is 5-5.5. The increased constancy of *Poa annua*, *P. trivialis*, and *Lolium perenne* was found, too.

Increased constancy and cover values among the nitrophilous species as *Stellaria media* and *Tripleurospermum inodorum* was observed in both associations. In certain areas nitrophilous species, e.g. *Euphorbia helioscopia* and *Veronica persica* in the *Caucalido-Scandicetum*, and *Papaver rhoeas* and *Plantago intermedia* in the *Vicietum tetraspermae* also spread (Tables 3 and 4, Fig. 6e). Some of the characteristic species of the *Caucalidion* alliance (*Aethusa cynapium*, *Silene noctiflora*, *Delphinium consolida*, and *Valerianella dentata*) increased constancy degrees (Tables 1 and 3).

Changes in percentage of various groups of species (= changes in division of ecological niche of the community) - Two types of changes

Since the size of individuals of a given species is proportional to the amount of resources consumed (HARPER 1977) and the size of individuals is proportional to their cover, hence the cover of a particular group of species may exemplify their role in the stand. Based on the sums of cover values in the same or neighbouring plots the role of a particular group of species in a given time can be stated (Figs. 5 and 6). The most striking similarity between stands in 1986-88 is the domination of cereals in part of them (Figs. 5b and 6b). The weeds, especially grasses, were dominating in another part of stands (Fig. 5d and 6c-f). The main difference between communities is the dominant role of *Avena fatua* in the impoverished *Caucalido-Scandicetum* association, and of e.g. *Apera spica-venti* or *Agropyron repens* in the transformed *Vicietum tetraspermae* association. Taking this into consideration the two types of changes in weed-communities of grain crops from 1947-1988 may be distinguished: 1) when the part of the ecological niche of weeds was replaced by cereals, and 2) when the part of the ecological niche of dicotyledonous weeds and cereals was replaced by other strong competitive weeds, mainly grasses. It depends on various factors (type of soil, its humidity, pH, length of stem of a cereal, etc.), which species will compete the other ones. This is known as the "compensation effect" (SWIETOCHOWSKI and ROLA 1961, HOLZNER and IMMONEN 1982). The types of changes are connected with extinction of characteristic species of the *Caucalido-Scandicetum* and *Vicietum tetraspermae* associations and the *Centauretalia cyani* order. There also withdraw small, light-loving, competitively weak species (acidophilous, hygrophilous of the *Isoëto-Nanojuncetea* or calcicolous and thermophilous weeds and xerothermic grassland species), depending on the type of habitat. It seems that the species mentioned are threatened due to shading, having no significance if it is cereal or grass-weed which shades them. A small amount of species of the

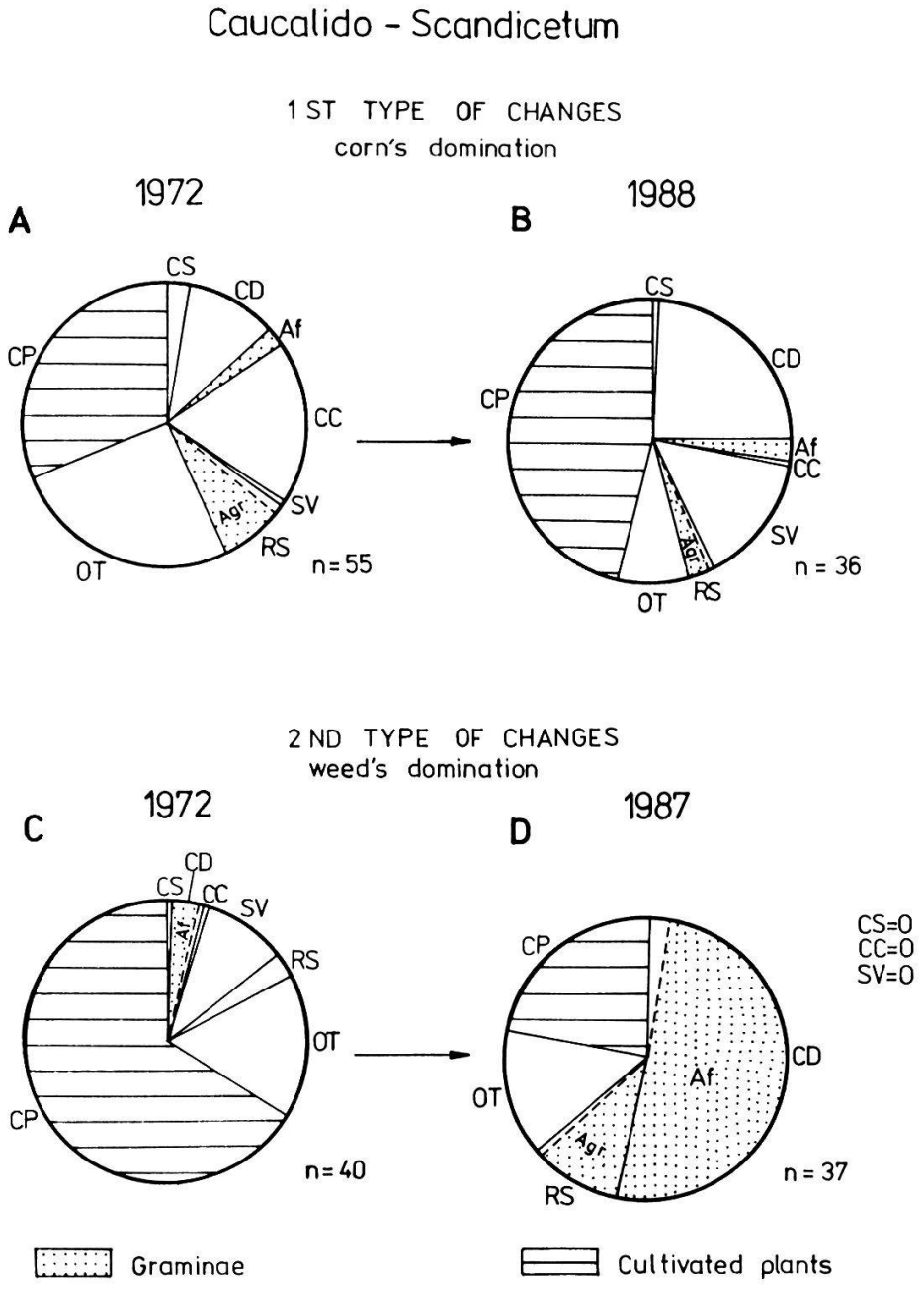

Fig. 5. Changes in the ecological niche division among particular groups of species, expressed as the sums of their average cover in exemplary relevés. Locality: Moczydlo.
In 1972 (A) and in 1987 (B) relevés were made in the same 100 m^2 area, No. of plot 1. In 1972 (C) and in 1987 (D) relevés were made in the same 100 m^2 area - No. of plot 12.
CP - cultivated plants, CS - *Caucalido-Scandicetum*, CN - *Caucalidion*, CC - *Centaurea-talia cyani*, SV - *Secali-Violetalia arvensis*, RS - *Rudero-Secalietea*, OT - others, Af - *Avena fatua*, Agr - *Agropyron repens*, n - number of species in relevé, dotted area - percentage of grasses, striped area - percentage of cereals.

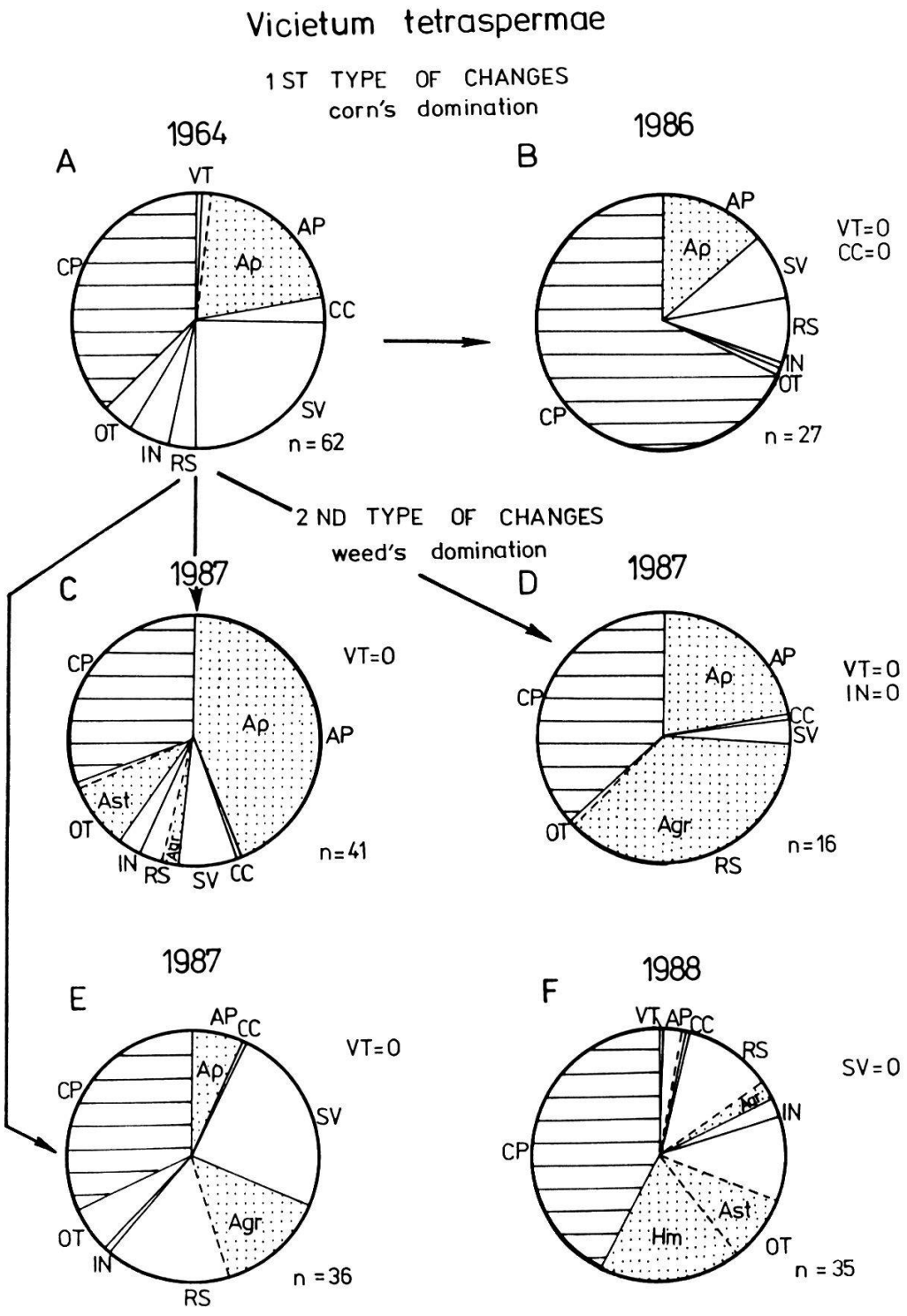

Fig. 6. Changes in the ecological niche division among particular groups of species, expressed as the sums of their average cover taken in exemplary relevés. Locality: Bukowki near Skala. relevés A (1964), B (1986), and C, D, E (1987) were done in neighbouring fields. Relevé made in 1988 (F) is originated from Dabrowa near Zachwyt valley. Area of relevés - 100 m^2. AP - *Aperion*, VT - *Vicietum tetraspermae*, IN - *Isoëto-Nanojuncetea*, Ap - *Apera spica-venti*, Ast - *Agrostis gigantea*, Hm - *Holcus mollis*, other as in Fig. 5.

Secali-Violetalia arvensis order and the more abundant species with high constancy of the *Rudero-Secalietea* class persist in both types of changes.

4. CAUSES OF CHANGES IN SEGETAL COMMUNITIES

The most general cause of changes described is the shifting of cultivation measures (ROLA 1973). However, certain agricultural treatments have a more distinct impact on changes in corn-weed communities than on other ones.

- The increase in cover of cereals, mainly by introducing new cultivars which strongly tiller. Their dense cover prevents the soil from desiccation. In shady places the thermophilous and calcicolous species as well as other species of small size are eliminated.
- The high rates of mineral and organic fertilizers have brought about the increase of soil pH where the *Vicietum tetraspermae* association is developed (Table 2). This may be a cause for the withdrawal of acidophilous species. However, the enhanced cover of the *Caucalido-Scandicetum* association and the accumulation of organic materials lead to a decrease of pH value (Table 1). The ploughing of fields soon after harvest and the sowing of the second crops, which shade the soil, favour the accumulation of humus in cretaceous rendzinas. The high rates of mineral fertilization promotes the nitrophilous species and weed-grasses.
- The common and continuous use of herbicides eliminates the majority of dicotyledons. Only a few species are probably resistant to their action thrive (e.g. *Tripleurospermum inodorum* and *Convonvulus arvensis*).
- The use of qualified grains, i.e. sowing of all fields with grain having no diaspores of weeds, is the cause for the withdrawal of speirochoric species.
- The shift in land use is the most important cause for changes in segetal communities. It may turn the fields of grain-crops into pastures, meadows, orchards, gardens or abandoned fields.

  Depending on site conditions, the field is overgrown by successional series leading to forest communities or xerothermic grasslands. Fields too dry or too steep for cultivation are favourable habitats for thermophilous and calcicolous species. Fallow lands play an important role in the changes of the *Caucalido-Scandicetum* association. The species of *Caucalido-Scandicetum* have still grown in the abandoned fields for 1-2 years (e.g. *Allium rotundum* in Skorocice). Abandoned fields are colonized later by the species from xerothermic grasslands (e.g. *Aster amellus* and *Brachypodium pin-*

natum in Widnica) and by species which were in the grain-crops (e.g. *Melampyrum arvense*). In this way an old-field turns into poor xerothermic grassland. Since the *Vicietum tetraspermae* association is widespread, the changing of cultivation measures and abandoning of fields where this community occurs is of less significance.

5. DISCUSSION

The changes in the segetal communities are largely described and the diminishing number of species in relevés and their withdrawal are stressed (e.g. HOLZNER and IMMONEN 1982, KORNAS 1987a and literature cited there). This concerns above all speirochoric species, species of the *Centauretalia cyani* order (KORNAS 1987a,b, SVENSSON and WIGREN 1982, 1983a,b 1985a,b), species in extreme site conditions, calcicolous and thermophilous (HOLZNER and IMMONEN 1982, KOCK 1984, WAGENITZ and MAYER 1981, WNUK 1989), and acidophilous species (HILBIG 1987, MEISEL 1985, WOJCIK and KMOSEK 1988). The withdrawal of the other groups is described rarely and seems to have rather local importance, e.g. diminishing of meadow species in the Gorce Mts. (KORNAS 1987a). Weeds with increasing percentage of cover are the same species or belong to the same ecological groups. The spreading of grasses is frequently stressed: *Avena fatua* (CHANCELLOR and PETERS 1972, FRYER 1983, KAPELUSZNY 1981, KORNIAK 1985, MORTIMER 1983, THURSTON 1982, RAUBER and KOCH 1975, WILSON and CUSSANS 1975), *Apera spica-venti* (ELLENBERG 1978, KUKOWSKI 1978, KAPELUSZNY 1981, PAWLOWSKI and WESOLOWSKI 1982, WARWICK et al. 1985). *Agropyron repens* is also expanding in some areas (CUSSANS 1973, ELLENBERG 1978, HAKANSSON 1982, KORNAS 1987, MORTIMER 1983). Other spreading species are *Agrostis gigantea*, *Holcus mollis*, *Poa annua*, *Poa trivialis* (FRYER 1983, KORNAS 1987). Besides the external factors of grasses spreading connected with cultivation measures, the great intrapopulation variability of these species which enables their fitting to environmental changes was noted for *Apera spica-venti* (WARWICK et al. 1987) and for *Avena fatua* (DARMENCY and AUJAS 1987, IMAM and ALLARD 1965, TRENBATH 1977, WHALLEY and BURFITT 1972). The increasing role of the nitrophilous species (HILBIG 1987, WOJCIK and KMOSEK 1988) and of the species of the *Caucalidion* alliance (SCHUBERT 1986) was also stressed. In general, almost all authors give similar explanations for the changes described (see Chapter 4). The role of the grain-qualification process in the speirochoric species (KORNAS 1987b) seems to be proved and the impact of

the high rates of mineral fertilization is also clear (BOROWIEC et al. 1974, PAWLOWSKI and WESOLOWSKI 1981). The use of herbicides affects negatively dicotyledons and promotes the growth of grasses, i.e. compensation (SWIETOCHOWSKI and ROLA 1961, HOLZNER and IMMONEN 1982). SZOTKOWSKI (1989) noted that the herbicides in Opole Silesia were first used in 1957, and in the next years their amount increased, especially in 1970-1975. In 1970 307.7 t of herbicides were used in the Opole province, in 1975 850 t and in 1980 782 t. The role of new cultivars of cereals introduced, increasing their cover, was stressed by WNUK (1989) and the promotion of *Apera spica-venti* by winter wheat monoculture by PAWLOWSKI and WESOLOWSKI (1982).

6. CONCLUSIONS

The results obtained and the information from literature leads to the following conclusions: The *Caucalido-Scandicetum* and *Vicietum tetraspermae* associations, which occur in segetal communities in the southern part of the Malopolska Upland, underwent great changes from 1947-1948 to 1986-1988. The *Caucalido-Scandicetum* association almost completely disappeared and was replaced by the community of the *Caucalidion* alliance or by the association with the strong domination of cereals (Fig. 5b) or *Avena fatua* (Fig. 5d). The evolution of the *Vicietum tetraspermae* association was more differentiated. The stands with the characteristic species of the association could rarely be found. The stands with the domination of cereals (Fig. 6b) or *Apera spica-venti* (Fig. 6c) were most frequent, the stands with the domination of *Agropyron repens* (Fig. 6g,d) and nitrophilous species (Fig. 6e), were less frequent; the stands with *Holcus mollis* (Fig. 6f) occurred only sporadically.
The mechanism of the changes mentioned was as follows: from 1947-1948 to 1972-1975 the cover of cereals continuously increased and in consequence the cover of weeds decreased. The species started to withdraw, however, they were still present, but scattered. Simultaneously, in 1970-1975, the use of herbicides was twofold enhanced (SZOTKOWSKI 1989). Acting together, these factors brought about the intensification of the process of decreasing the number of species (Tables 1 and 2) and their extinction, predominantly those characteristic of the associations and the *Centauretalia cyani* order.
After a few years of soil seed-bank accumulation and/or vegetative propagation the rest of the weed-grasses used the created ecological niche and could dominate in the community (i.e. the process of compensation occurred).

In spite of the changes in the community species composition, the new communities, poorer in species, were created according to the soil types diversification. The results obtained clearly show that the plant association is a certain unstable spatial-temporal configuration; its species composition and quantitative ratios fluctuate according to the changes of the factors influencing them (in this case the changes are predominantly brought about by shifting in cultivation management treatments).

SUMMARY

Changes in the two main corn-weed communities (*Caucalido- Scandicetum* and *Vicietum tetraspermae* associations) in the southern part of the Malopolska Upland were investigated as well as the mechanisms: through the increased cover of cereals and the decreased cover of weeds from 1947-1948 to 1972-1975 (Tables 1 and 2, Figs. 2 and 3) the number of species in the communities considerably diminished, especially in 1975-1988 (Tables 1 and 2, Fig. 4). Speirochoric species, calcicolous, thermophilous, and acidophilous species (depending on the type of habitat), the heliophilous, competitively weak species and species growing in wet furrows are withdrawing or extinct. The characteristic species of the *Centauretalia cyani* order and the *Caucalido Scandicetum* and *Vicietum tetraspermae* associations withdrew (Table 3 and 4). Depending on the type of habitat weed-grasses, predominantly *Avena fatua*, *Apera spica-venti*, *Agropyron repens* and *Holcus mollis* spread (Tables 3 and 4, Figs. 5 and 6) and nitrophilous species expanded (Table 3 and 4, Fig. 6e). In spite of this certain species of the *Caucalidion* alliance increased their constancy (Tables 1 and 3). Based on the results, two types of community changes were distinguished: 1) domination of cereals in the ecological niche of the withdrawing weeds (Figs. 5b and 6b), 2) domination of weeds, usually grasses, depending on the soil type and other ecological conditions (Figs. 5d, 6c-f). It seems that these two types of changes, which presumably exist in other areas, inferring from the literature about the widespread occurrence of weed-grasses, form a new and stable ecological system. The data obtained show that the corn-weed plant associations, which are unstable and vulnerable ecological systems, undergo quantitative (species abundance ratios) and qualitative (changes in species composition) alterations, influenced by changes in agriculture measures.

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