

Instytut Biologii UMCS, Zakład Geobotaniki

FLORIAN ŚWIĘS

Expansion of *Puccinellia distans* (Jacq.) Parl.
in the city of Tarnów

Ekspansja *Puccinellia distans* (Jacq.) Parl. na terenie miasta Tarnowa

INTRODUCTION

Puccinellia distans belongs to the species of the Euro-Siberian element characteristic of naturally or secondarily highly salted habitats (8, 9, 16, 26). It is found in almost the whole of Europe and in the western-central-northern part of Asia and in the north-western periphery of Africa (8, 11). In Poland natural habitats of this plant occur in inland areas with saline water heads and in salted seaside habitats (11). On the global scale *Puccinellia distans* spreads, by being brought in, in secondarily salted anthropogenic habitats, in the vast expanses of Europe, Asia and North America (2, 8–11, 16, 20, 26). In Poland the first brought-in stations of *Puccinellia distans* on anthropogenic salted habitats were reported in the first half of the 19th c. (11). Intense domestic expansion of *Puccinellia distans* started as late as on the turn of the 1970's, which is basically due to the progressing salinity and contamination of the substratum caused by the increasingly frequent use of salt to remove snow from streets, squares and other areas (2, 11, 16, 26–28). Currently *Puccinellia distans* as a brought-in species has spread in many regions of Poland, the relatively smallest extent being in the Carpathians, Sandomierz Basin, in Polesie and in Lakelands (11).

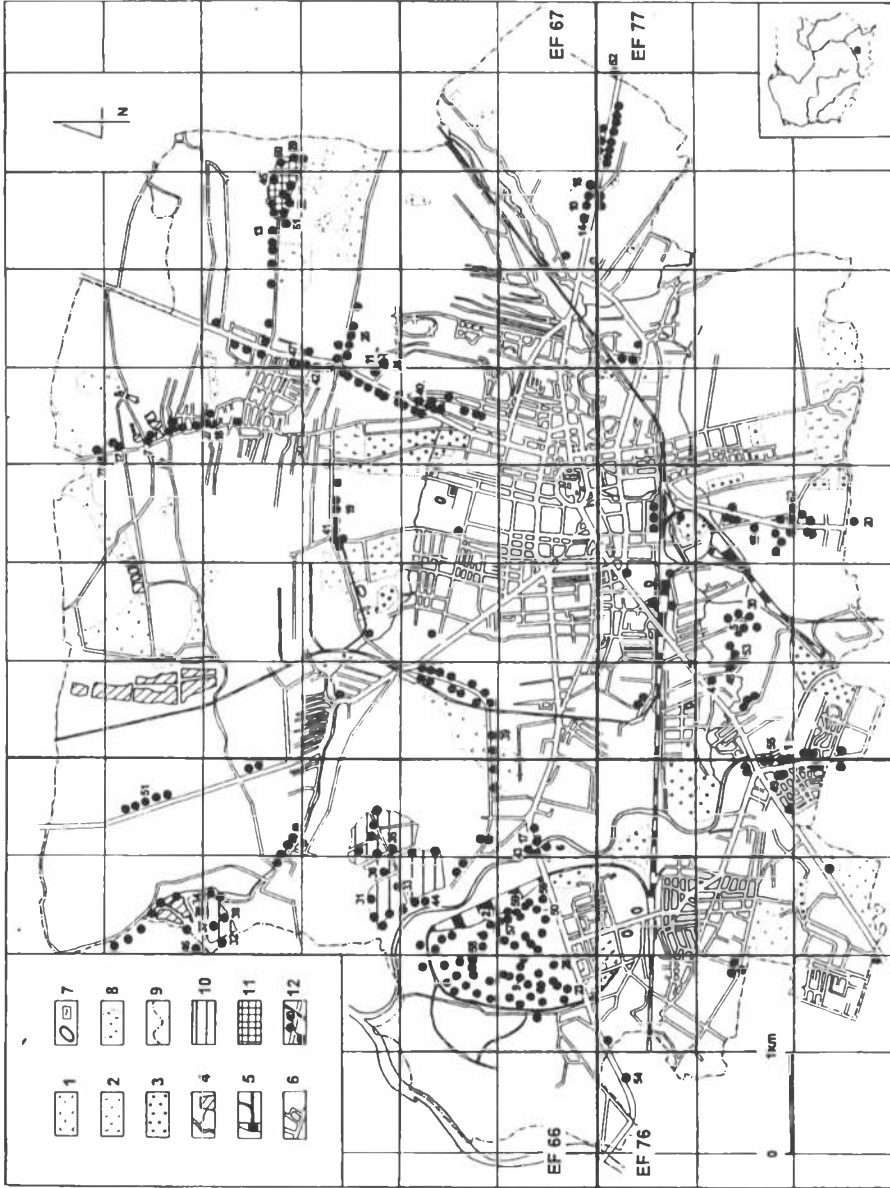


Fig. 1. Map of *Puccinellia distans* occurrence in Tarnów. 1 — city parks, 2 — garden plots, 3 — forests, 4 — river network, ponds, 6 — roads, 7 — sports stadiums and swimming pools, 8 — cemeteries, 9 — factory water sedimentation tanks, 10 — municipal landfill, 11 — stations of *Puccinellia distans*, in phytosociological records (nos. 1–52) and outside them (not numbered). NB. Map made on the ATPOL grid

INVESTIGATION AREA

The Town of Tarnów has an interesting history of development in respect of architecture, culture and education, administration, industries and tourism (17, 27, 29). It is also characterized by many specific features of urban and general environment (6, 12, 14, 18, 23, 27, 29–30). The town covers the area of 7,238 ha and numbers over 107,000 inhabitants. It is situated on the southern margin of Sandomierz Basin, where three regions meet: Wojnice Plateau, the converging valleys of the Biała Dunajcowa and Dunajec rivers, and Tarnów Plateau. The built-up areas of Tarnów are basically situated on a wide plain, at times slightly undulating and transected with deep river valleys, at 240–280 m above sea level. On the national scale Tarnów belongs to few towns that are characterized by the warmest and driest climate, continental rather than oceanic. The average annual air temperature ranges between 8.2–8.3°C while the average annual precipitation ranges 650–700 mm. The warmest month is July (18°C), the coldest is January (–4.5°C). Moreover, a distinguishing mark of the Tarnów region is its exceptionally long vegetation season that lasts 210–220 days. The natural soil substratum in Tarnów is usually highly permeable, lime-free and deficient in nutrients for plants. Most often these are sandy-gravel, loamy-sandy, dusty-sandy or sandy formations.

In Tarnów, the largest and at the same time environmentally most noxious industrial object is the Nitrogen Works built in 1923–1924. Nitrogen compounds emission from the plant causes exceptionally high contamination of the urban environment (18, 23, 27). Noteworthy in Tarnów are also intersections of major sub-Carpathian and national railroad and road transport routes with four PKP (Polish Railroad) stations and two PKS bus stations.

GOAL AND METHODS OF INVESTIGATION

The present study has characterized the dynamics of expansion in Tarnów of *Puccinellia distans* as an accidentally brought-in plant, permanently settling in anthropogenic, secondarily salted habitats. The first records of occurrence of *Puccinellia distans* in Tarnów come from 1985 and 1986 (27). Currently, intensive field studies on *Puccinellia distans* occurrence within the town of Tarnów were conducted during vegetation seasons in 1995 and 1996. All the hitherto located stations of *Puccinellia distans* in the area of Tarnów were presented in Fig. 1.

Phytosociological studies on the currently identified phytocenoses in Tarnów, characterized by the presence of *Puccinellia distans* were conducted according to the generally accepted phytosociological methods (24). The investigations were documented with 62 phytosociological records. The records were listed in Tables 2–5, their spatial distribution being shown in Figure 1.

Syntaxonomic structure of the investigated plant communities was given mainly after Matuszkiewicz (19), less frequently after Oberdorfer (22), Rivez-Martinez (25) and Świąś (27, 28). Nomenclature of the listed bryophytes as well as pteridophytes and flower plants was given according to two successive studies cited on the subject (15, 21).

In the fall of 1996 ten soil samples were taken from the best formed expanses of the plant communities under investigation. They come from the substratum level with the highest rooting of dominant species and at the same time most characteristic of the community. In the Provincial Soil-testing Station, Lublin, in the soil samples collected there were determined: *pH* (using type-N-512 *pH*-meter) and the contents of: P₂O₅ and K₂O contents (using Egner and Rhiem method), Ca, Cl and N–NO₃ (using the potentiometric method), Na and Mg (with the photometric method) and general salinity (with the conductimetric method). The results of chemical soil analyses carried out according to the methods collected by Czuba (1) were specified in Table 1.

profile	Number of		pH in H ₂ O/deest. in KCl	C o n t e n t i n m g / l							salinity in g KCl/l
	community	records		N-NO ₃	P ₂ O ₅	K ₂ O	Ca	Mg	Na	Cl	
1	1.	1	7,5 7,3	29,2	12	156	5010	185	140	35,0	0,09
2	2.1.2.	8	7,7 7,2	38,8	34	168	5060	220	110	23,8	0,18
3	2.2.2.	26	7,5 7,4	31,6	46	36	5010	110	400	60,0	0,18
4	2.2.2.	29	7,4 7,3	43,7	69	1452	4080	250	620	106,5	0,15
5	3.5.	38	6,8 6,2	0,3	879	242	6700	167	300	128,3	0,45
6	4.1.	39	7,6 7,2	52,0	34	84	5010	190	90	53,0	0,12
7	4.1.	41	7,6 7,5	33,8	92	78	5040	140	90	15,3	0,09
8	4.1.	45	7,3 7,2	8,9	34	60	3820	185	20	13,0	0,09
9	4.2.	53	7,5 6,8	42,9	12	132	5000	215	1820	171,8	2,04
10	4.2.	58	7,2 7,0	8,5	58	108	3900	95	40	25,4	0,12
11	4.2.	59	6,7 6,3	6,5	34	24	1800	100	*	3,3	0,09

Table 1. Some chemical properties of soils in Tarnów area among ruderal communities with *Puccinellia distans*. Attention. The data of chemical analyses of soils samples collected at the depth of 5–15 cm

In Poland similar investigations of the expansion of *Puccinellia distans* were conducted earlier in the areas of Kraków (Cracow, 21), Poznań (10) and Lublin (28).

The Phytosociological Characteristics of Phytocenoses with *Puccinellia distans*

LIST OF PHYTOCENOSES

In Święs' (27) phytosociological characteristics of the whole of synanthropic plant communities in the town of Tarnów as few as nine phytosociological records of four phytocenoses, included in the study, show the presence of *Puccinellia distans*. These are the following phytocenoses:

Association: *Polygono-Bidentetum* (Koch. 1926) Lohm. 1950 in a variant with *Bidens tripartitus* (Table 2, rec. 8, 9).

Association: *Puccinellietum distantis* Knap 1948 in a variant with *Lepidium ruderales* and *Puccinellia distans* (Table 3, rec. 44–45).

Association: *Senecioni-Tussilaginetum* Moller 1949 (Table 7, rec. 96, 108, 109).

Community: with *Lactuca serriola* and *Chenopodium album* in a variant with *Lactuca serriola* and *Chenopodium album* (Table 8, rec. 128).

It follows from the present studies on *Puccinellia distans* occurrence in the area of Tarnów that the presence of the plant in question was found in the following five phytocenoses (Table 2–4):

1. Association: *Potentilletum anserine* Rapaics. 1927
2. Association: *Lolio-Plantaginetum* (Beg. 1930) Siss. 1969
 - 2.1. subassociation: *L.-P. typicum* F. Świąs
 - 2.1.1. variant: with *Artemisia vulgaris*
 - 2.1.2. variant: typical
 - 2.2. subassociation: *L.-P. puccinellietosum* Tx. 1970
 - 2.2.1. variant: with *Plantago major*
 - 2.2.2. variant: typical
3. community with *Bryum argenteum* and *Puccinellia distans*
 - 3.1. form: with *Plantago intermedia* and *Fumaria hygrometrica*
 - 3.2. form: typical
 - 3.3. form: with *Calamagrostis epigeios*
 - 3.4. form: with *Cerastium vulgatum* and *Sisymbrium officinale*
 - 3.5. form: with *Solidago gigantea*
4. Association: *Plygono-Matricarietum discoideae* (Siss. 1969) Tx. 1972
 - 4.1. subassociation: *P.-M. d. typicum* subass. nove
 - 4.2. subassociation: *P.-M. d. puccinellietosum* Gutte (1966) 1972
5. community: with *Medicago lupulina*

For the sake of clarity it should be also added that the two phytocenoses characterized earlier (27) with the presence of *Puccinellia distans* ranking as the association *Puccinellietum distantis* and communities with *Lactuca serriola* and *Chenopodium album* should be assigned to the subassociation *Polygono-Matricarietum discoideae puccinellietosum* and the association *Erigeronto-Lactucetum* respectively. Moreover, among the four phytocenoses characterized earlier with the presence of *Puccinellia* (27) only the subassociation *Polygono-Matricarietum discoideae* was at present characterized more broadly in the new stations of phytosociological records (Table 3).

THE SURVEY OF PHYTOCENOSES

1. *Potentilletum anserinae*

(Table 2, rec. 1)

In the only expanse found of this association *Potentilla anserina* undividedly dominates over other plant species. This dominant is regarded as the main species characteristic of this association. Among other rarely recorded species only *Polygonum aviculare* has the relatively highest occurrence.

Phytosociological record: 1. Koszycka St., the roadside with a low-beaten, dry humous-sandy-loamy surface.

Table 2. Phytosociological structure: I. — association *Potentilletum anserinae*, 2.1. — sub-association *Lolio-Plantaginetum typicum* in variants — 2.1.1. with *Artemisia vulgaris*, 2.1.2. — typical — syntaxonomic groups only with sporadic species, listed at the bottom

Number of community	1.					2.					1.	2.1.	
	1	2	3	4	5	1.	2.	3.	4.	5.			
Number of record	1	2	3	4	5	7	8	9	10	11	12	Frequency	Presence
Date	95-08-17	95-08-17	95-08-12	95-08-12	95-08-15	95-08-12	95-08-12	95-08-12	95-08-15	95-08-15	95-08-15		
Area of plot in m ²	2	2	4	6	12	12	16	16	10	3	6		
Cover the layer in %	C D	C D	C D	C D	C D	C D	C D	C D	C D	C D	C D		
Number of species in record	5	13	24	19	12	11	17	13	12	10	14		
<p>I. Ch: a - Isoëto-Nanojuncetea, b - Bidentetea tripartiti (x)</p> <p>■ <i>Plantago intermedia</i> I</p> <p>II. Ch: a - Molinio-Arrhenatheretea, b - Trifolium fragiferi-Agrostietalia, Agropyro-Rumicium crispi, c - Plantaginetalia majoris, Lolio-Plantaginion</p> <p>■ <i>Taraxacum officinale</i> III</p> <p>■ <i>Trifolium repens</i> III</p> <p>■ <i>Achillea millefolium</i> IV</p> <p>■ <i>Leontodon autumnalis</i> II</p> <p>b <i>Potentilla anserina</i> (Ch: ass. 1)..... 5 1</p> <p>b <i>Agrostis gigantea</i> 2 II</p> <p>c <i>Plantago major</i> (Ch: ass. 2) + 1 2 2 2 2 4 4 4 4 4 4 1 V</p> <p>c <i>Lolium perenne</i> (Ch: ass. 2) + 2 V</p> <p>III. Ch: a - Polygono-Poëtea annuae, b - Puccinellion maritimae</p> <p>■ <i>Polygonum aviculare</i> 2 + 1 2 1 1 II</p> <p>■ <i>Bryum argenteum</i> + + + II</p> <p>■ <i>Poa annua</i> + + 2 2 1 IV</p> <p>■ <i>Lepidium ruderales</i> + + + II</p> <p>■ <i>Chamomilla suaveolens</i> + + + III</p> <p>b <i>Puccinellia distans</i> + + 1 + + 2 1 + 1 V</p> <p>IV. Ch: a - Secalietea, b - Chenopodietea, c - Artemisietea vulgaris</p> <p>a <i>Metricaria maritima</i> subsp. inodora .. + + + II</p> <p>b <i>Sonchus oleraceus</i> + r + + III</p> <p>b <i>Lactuca serriola</i> + r r + II</p> <p>b <i>Chenopodium album</i> + r + I</p> <p>b <i>Echinochloa crus-galli</i> + + + II</p> <p>b <i>Atriplex patula</i> + + + I</p> <p>b <i>Setaria pumila</i> + + + I</p> <p>c <i>Daucus carota</i> r + + II</p> <p>c <i>Artemisia vulgaris</i> + + + r r IV</p> <p>c <i>Arctium lappa</i> r + + II</p> <p>c <i>Tanacetum vulgare</i> + + + II</p> <p>c <i>Melilotus alba</i> r + + II</p> <p>V. Ch: a - Agropyreteo repentis, b - Festuco-Brometea (x), c - Sedo-Scleranthetea</p> <p>■ <i>Capsella bursa-pastoris</i> r + + 1 I</p> <p>c <i>Ceratodon purpureus</i> + + + I</p> <p>VI. Others</p> <p><i>Conyza canadensis</i> 2 2 + + r III</p> <p><i>Agrostis capillaris</i> 2 2 + + III</p> <p><i>Medicago lupulina</i> + + + 1 IV</p>													
Species occurring in 1 record:													
<p>Ib - <i>Chenopodium glaucum</i> 8/r. IIA - <i>Holcus lanatus</i> 3/+, <i>Trifolium pratense</i> 3/+, <i>Phleum pratense</i> 10/+. IIB - <i>Rumex crispus</i> 2/+, <i>Potentilla reptans</i> 3/+. IVb - <i>Descurainia sophia</i> 6/+, <i>Polygonum persicaria</i> 6/+, <i>Sonchus asper</i> 10/r. IVa - <i>Solidago gigantea</i> 3/r. Va - <i>Cirsium arvense</i> 3/r, <i>Tussilago farfara</i> 3/1, Vb - <i>Diploxys muralis</i> 2/+. VI - <i>Picris hieracioides</i> 2/+, <i>Vicia grandiflora</i> 3/+, <i>Hypochoeris radicata</i> 10/r, <i>Pleurozium schreberi</i> 11/+, <i>Polytrichastrum formosum</i> 11/+, <i>Pohlia nutans</i> 11/+, <i>Senecio jacobaea</i> 12/r.</p>													

2. *Lolio-Plantaginetum*

(Table 2–3, rec. 2–29)

The association under investigation is formed in two subassociations, each of them having two separate variants. The main part in the association is played by *Plantago major* and *Puccinellia distans*.

2.1. *Lolio-Plantaginetum typicum*

(Table 2, rec. 2–12)

This association is primarily characterized by a fairly considerable quantitative domination of *Plantago major* over *Puccinellia distans*. Two variants were distinguished. The variant with *Artemisia vulgaris* differs from the typical variant: by a far greater percentage of species of *Artemisietea vulgaris* class and noticeably lesser density of *Plantago major*.

Moreover, the two variants are characterized by specific but weakly differentiated facies. This applies chiefly, in the variant with *Artemisia vulgaris*, to facies with *Coryza canadensis* (rec. 2), with *Coryza canadensis* and *Agrostis capillaris* (rec. 3), with *Agrostis capillaris* (rec. 4), with *Agrostis gigantea* (rec. 5) and typical with *Plantago major* (rec. 6), and in the typical variant, to facies with *Polygonum aviculare* (rec. 7), with *Trifolium repens* and *Poa annua* (rec. 8), with *Poa annua* and *Lolium perenne* (rec. 9) and the typical facies with *Plantago major* and other species (rec. 10–12).

2.2. *Lolio-Plantaginetum puccinellietosum*

(Table 3, rec. 13–29)

This subassociation is primarily characterized by a decidedly quantitative domination of *Puccinellia distans* and *Plantago major*. Two variants were distinguished. In the variant with *Plantago major* there is a slight quantitative domination of *Plantago major* over *Puccinellia distans*, while in the typical variant there is a clear quantitative domination of *Puccinellia distans* over *Plantago major*. At the same time the two variants are characterized by specific but weakly differentiated facies systems. In the variant with *Plantago major* these are mainly facies: typical with *Plantago major* (rec. 13–17), with *Polygonum aviculare* (rec. 18–20), and in the typical variant this applies to facies with *Poa annua* (rec. 21), typical with *Puccinellia distans* (rec. 22–24), with *Plantago major* (rec. 25–28) and with *Plantago major* and *Echinochloa crus-galli* (rec. 29).

In Tarnów the association *Lolio-Plantaginetum* characterized with the presence of *Puccinellia distans* occurs rather rarely, in expanses up to one are. It

Table 3. Phytosociological structure: 2.2. — sub-association *Lolio-Plantagininetum puccinellitosum* in variants — 2.2.1. with *Plantago major*, 2.2.2. — typical (x) — as in Table 2

Number of community	1.		2.		N. N.
	1.	2.	2.	2.	
Number of record	13	14	15	16	Constancy
Date	96-08-15	96-08-13	96-08-15	96-08-12	
Area of plot in m ²	4	2	4	4	C
Cover the layer in %	90	100	100	100	
D	D
Number of species in record	11	16	10	8	
I. Ch: Iso#to-Nanojuncetea, b - Bidentetea tripartiti a <i>Plantago intermedia</i> + + + + I b <i>Chenopodium rubrum</i> + + + + I					
II. Ch: a - Molinio-Arrhenatheretea, b - Trifolio fragiferi-Agrostietalia, Agropyron rumiclon crispi, c - Plantaginietalia majoris, Lolio-Plantaginion a <i>Trifolium pratense</i> + + + + I a <i>Trifolium repens</i> + + + + II a <i>Leontodon autumnalis</i> + + + + II a <i>Achillea millefolium</i> + + + + III a <i>Taraxacum officinale</i> + + + + III a <i>Dactylis glomerata</i> + + + + I b <i>Potentilla anserina</i> + + + + I b <i>Rumex crispus</i> + + + + I					
c <i>Lolium perenne</i> (Ch: ass. 2) 1 1 + + + + . 1 1 + 1 + III c <i>Plantago major</i> (Ch: ass. 2) 3 3 3 3 3 3 3 3 2 + + 1 2 2 2 2 2 V					
III. Ch: a - Polygono-Poëtea annuae, b - Puccinellion maritima a <i>Polygonum aviculare</i> 1 + 1 + + 2 2 2 + + 1 + + V a <i>Poa annua</i> + + 2 2 + III b <i>Puccinellia distans</i> 4 4 4 5 5 4 4 4 5 5 5 5 4 5 5 3 5 V					
IV. Ch: a - Secalietea (x), b - Chenopodietea, c - Artemisietea b <i>Echinochloa crus-galli</i> + + + + 2 II b <i>Sonchus oleraceus</i> + + + + II c <i>Tanacetum vulgare</i> + + + + I c <i>Mellilotus albus</i> + + + + I c <i>Artemisia vulgaris</i> + + + + II c <i>Pastinaca sativa</i> + + + + I c <i>Daucus carota</i> + + + + I					
V. Ch: a - Agropyretea repentis (x), b - Festuco-Brometea (x), c - Sedo-Scleranthetea c <i>Ceratodon purpureus</i> + + + + I					
VI. Other <i>Medicago lupulina</i> + + + + II <i>Agrostis capillaris</i> 1 + + 1 1 II					
Species occurring in 1 record:					
Ib - <i>Chenopodium glaucum</i> 14/r, <i>Bidens tripartita</i> 28/+. IIa - <i>Plantago lanceolata</i> 14/+. Iib - <i>Ranunculus repens</i> 13/+. IIIa - <i>Chamomilla suaveolens</i> 20/+, <i>Bryum argenteum</i> 26/+. IVa - <i>Bromus secalinus</i> 20/r, <i>Matricaria maritima</i> ssp. <i>inodora</i> 27/+. IVb - <i>Galinsoga ciliata</i> 18/+, <i>Chenopodium album</i> 21/+, <i>Setaria pumila</i> 21/+, <i>Polygonum persicaria</i> 28/r, <i>Sonchus asper</i> 29/r. Va - <i>Cirsium arvense</i> 28/+. Vb - <i>Medicago falcata</i> 20/r. VI - <i>Conyza canadensis</i> 14/+, <i>Hypochoeris radicata</i> 26/+, <i>Senecio vulgaris</i> 28/+.					

develops mainly on the rims of highways, on the roads and squares on the substratum with a highly beaten surface, most often highly overdried, with a mechanical composition of sandy deposits with different admixtures of gravel, clay, rock grains, brick etc.

Phytosociological records: 2. Nitrogen Works, a square with a sandy-gravelly

surface. 3. Nowodąbrowska St., a driveway with a gravelly-loamy-sandy surface with scant brick grains. 4. Fabryczna St., the roadside with a slightly convex, gravelly-sandy surface. 5. Near Przemysłowa St., the fringe of a ruderal square with a gravelly-sandy-loamy surface. 6. Nitrogen Works, the fringe of a square with a sandy surface, constantly highly moistened. 7. Krzyska St., the roadside with a sandy-loamy surface. 8. The corner of Czerwona St. and Krakowska St., a weakly beaten driveway with a sandy-gravelly surface with scant brick grains. 9. Nitrogen Works, a small square with a loamy-sandy-gravelly surface. 10. Lwowska St., the roadside with a sandy-loamy-gravelly surface. 11. 16 Pułku Piechoty St., the roadside with a slightly lowered, sandy-gravelly surface. 12. The corner of Krzyska St. and Wisniowa St., the PKS bus depot, the fringe of a square with a gravelly-sandy surface. 13. Cmentarna St., the roadside with a sandy surface with a negligible gravel admixture. 14. Lwowska St., the roadside with a sandy-gravelly surface. 15. Tuchowska St., the roadside with a sandy-loamy surface. 16. Lwowska St., the roadside with a sandy-loamy surface with a negligible admixture of gravel. 17. Kwiatkowskiego St., the bridge of the Biała river, a wide crevasse in the bridge's concrete surface. 18. Krzyska St., the roadside with a sandy-loamy surface with a negligible gravel admixture. 19. Spokojna St., the roadside with a loamy-sandy surface with a negligible admixture of highly crushed furnace slag. 20. Tuchowska St., the roadside with a slightly concave sandy-loamy surface with a negligible gravel admixture. 21. Nitrogen Works, the fringe of a square with a sandy-gravelly-loamy surface with scant concrete grains and mortar. 22. Krzyska St., the roadside with a loamy-sandy surface. 23. Nitrogen Works, the fringe of a square with a sandy-loamy surface. 24. 16 Pułku Piechoty St., the roadside with sandy-loamy surface. 25. Błonie St., the roadside with a slightly concave, loamy-sandy surface with a scant admixture of gravel and highly wasted furnace slag. 26. Nitrogen Works, the fringe of a square with a sandy-gravelly-loamy surface. 27. Krzyska St., the roadside with a sandy-loamy surface with a scant gravel admixture. 28. Cmentarna St., the site of the municipal landfill, the roadside of a gravel road with a sandy-gravelly-loamy surface with brick grains. 29. Cmentarna St., the municipal landfill site, the roadside of a gravel road with a sandy-gravelly-loamy surface.

3. Community with *Bryum argenteum* and *Puccinellia distans*

(Table 4, rec. 30–38)

This community is distinguished primarily for the dense occurrence of bryophytes, with a far smaller density of flower plants. Five floristic forms were distinguished.

above. 37. Klikowa, the middle section of the dry floor of a water sedimentation tank, as in stations no. 31, 34. 38. Klikowa, as in stations no. 31, 34.

4. *Polygono-Matricarietum discoideae*

(Table 4–5, rec. 39–61)

In this association, mainly on account of differences in the quantitative occurrence of *Polygonum aviculare* and *Puccinellia distans*, two subassociations were distinguished, with several facies systems in each.

4.1. *Polygono-Matricarietum discoideae typicum*

(Table 4, rec. 39–51)

This subassociation is mainly characterized by decidedly quantitative domination of *Polygonum aviculare* over *Puccinellia distans*. Very weakly marked facies are composed chiefly of: *Bryum argenteum* (rec. 39), *Plantago major* (rec. 40–43), *Puccinellia distans* (rec. 44–45), typical of *Polygonum aviculare* (rec. 46–50) and of *Chamomilla suaveolens* (rec. 51).

4.2. *Polygono-Matricarietum discoideae puccinellietosum*

(Table 5, rec. 52–61)

The other subassociation is characterized by quantitatively diverse domination of *Puccinellia distans* over *Polygonum aviculare*. Four fairly marked facies are composed of the following plant species: *Polygonum aviculare* (rec. 52–54), *Polygonum aviculare* and *Bryum argenteum* (rec. 55), *Poa annua* and *Echinochloa crus-galli* (rec. 56–57) and *Puccinellia distans* (rec. 58–61).

The studied association occurs fairly frequently in the area under investigation but in small expanses. Like other phytocenoses with the presence of *Puccinellia distans* it is formed mainly on the rims of highways, roads and squares with a beaten surface, with intermittently highly diversified moistening or overdrying, with a mechanical composition of the sandy-loamy-gravelly type.

Phytosociological records: 39. Biała St., the roadside with a gravelly-sandy-loamy surface. 40. Nowodąbrowska St., the roadside with a gravelly-loamy-sandy surface. 41. Nowodąbrowska St., the roadside with a sandy-loamy surface with a scant admixture of gravel. 42. Kwiatkowskiego St., near the Biała river bridge, the rim of a driveway with a gravelly-sandy-loamy surface. 43. Spokojna St., the roadside with a sandy-loamy surface with a negligible admixture of gravel. 44. Klikowa, a weakly beaten country-road with a hard, dusty-sandy surface with negligible gravel. 45. Nowodąbrowska St., the roadside with a sandy-loamy-gravelly

surface. 46. Klikowa, as in station no. 44. 47. Cmentarna St., the site of the municipal landfill, the roadside with a sandy-gravelly surface. 48. Near Fabryczna St., a large ruderal square, the site with a slightly concave, loamy-sandy-gravelly surface. 49. Koszycka St., the roadside with a sand-turned loam surface. 50. Nitrogen Works, the roadside with a sandy-loamy-gravelly surface. 51. Klikowska St., the edge of a driveway with a gravelly-loamy-sandy surface. 52. Lwowska St., the roadside with a slightly concave, loamy-gravelly surface, covered with black mud. 53. Koszycka St., the sandy-surfaced roadside. 54. Witosa St., a roadside with a loamy-sandy-gravelly surface. 55. Fabryczna St., a square with a slightly lowered, loamy-sandy-gravelly surface. 56. Nitrogen Works, a square with a sandy-loamy surface, constantly highly moist. 57. Nitrogen Works, a square with a sandy-loamy-gravelly surface. 58. Nitrogen Works, a square with a gravelly-loamy-sandy surface, highly contaminated with toxic substances, particularly with mercury. 59. Nitrogen Works, a square with a sandy-loamy-gravelly surface. 60. Cmentarna St., the site of the municipal landfill, the rim of an old garbage heap with a loamy-sandy surface. 61. Cmentarna St., near Municipal Landfill Administration buildings, the edge of a square with a sandy-loamy surface with brick grains.

5. Community with *Medicago lupulina*

(Table 5, rec. 62)

In respect of the general species composition the community essentially resembles an intermediate phytocenose between communities of the order *Plantaginetalia majoris* and of the class *Artemisietea vulgaris*. The floristic composition of this community is characterized primarily by quantitative domination of *Medicago lupulina* over *Puccinellia distans*. Among other, quite numerous plant species in the community, the relatively most abundant are: *Daucus carota*, *Tusilago farfara* and *Ceratodon purpureus* and *Barbula unguiculata*.

Only one expanse of this community on the substratum highly unfavorable for plants was recorded in Tarnów.

Phytosociological record: 62. The corner of Tuchowska St. and Leliwitów St., a square with a highly beaten, gravelly-loamy-sandy surface with a considerable share of concrete and brick grains.

DISCUSSION OF RESULTS

In Tarnów *Puccinellia distans* as a brought-in species first appeared probably in the 1980's. This is corroborated by the absence of earlier reports concerning the occurrence of this plant in Tarnów in all publications on Tarnów

flora of 1853–1969 (3–5, 7). During the 1985–1986 investigations on the synanthropic plants of Tarnów 23 associations and seven phytosociologically indeterminate communities were reported, which were documented with 287 phytosociological records (26). In the published phytosociological materials collected in Tarnów the presence of *Puccinellia distans* was found only in nine phytosociological records of three associations: *Polygono-Bidentetum* in a variant with *Bidens tripartitus* (Table 2, rec. 8, 9), *Puccinellietosum-distantis* (= subassociation *Polygono-Matricarietum discoideae puccinellietosum* in a variant with *Lepidium ruderales* and *Puccinellia distans*) (Table 3, rec. 43, 44, 45), *Senecioni-Tussilaginietum* (Table 7, rec. 96, 108, 109) and in the community with *Lactuca serriola* and *Chenopodium album* (= association *Erigeronto-Lactucetum*) (Table 8, rec. 128). Moreover, sporadic occurrences were recorded of *Puccinellia distans* also outside the above-named phytocenoses, mainly on the fringes of narrow grass strips on the rims of Klikowska, Lwowska and Krakowska roads and among grasses of different height growing in the site of Nitrogen Works (Fig. 1). I do not know if the species occurred at that time in the area of the Nitrogen Works' water sedimentation tanks near Klikowa.

The heightened expansion of *Puccinellia distans* within Tarnów is essentially connected with the period of progressive salinification of the town's substratum as a result of more and more frequent use of salt for snow removal from various sites. In view of such conditions we can assert with high approximation that *Puccinellia distans* occurred in Tarnów in the 1980's in 10–20 stations, mostly growing there in scant numbers, rarely in numerous and larger tufts. At present we can report that in Tarnów *Puccinellia distans* occurs in several dozen single or group stations (Fig. 1). Among all the stations only eight are identical with the stations published earlier (27), the others correspond only to the recently discovered stations in 1995–1996 (Fig. 1). It turns out that in Tarnów *Puccinellia distans* exhibits the highest expansion only on the rim of the most-used roads. It occurs in relatively the highest numbers among the grasses in the squares in the area of Nitrogen Works and among grasses and on bryophytous substratum in different habitats near the Works' water sedimentation tanks (Fig. 1). It must be observed that the species exhibits rather high expansion on roadsides and the fringes of the municipal landfill established in 1984 (Fig. 1). However, in other habitats in Tarnów *Puccinellia distans* occurred only in one of the most littered squares near the railroad station (Fig. 1).

In Tarnów *Puccinellia distans* occurs in the total of eight associations and one phytosociologically indeterminate community (27), (Table 2–5). It occurs most often in initial ruderal grass and bryophytous communities ignored in phytosociological studies. In the above-named forms of the grass and bryophytous

community *Puccinellia distans* successively achieves greater and greater density, developing with time its most characteristic three phytocenoses: *Lolio-Plantagine-tum puccinellietosum* and *Polygono-Matricarietum discoideae puccinellietosum* and the community with *Bryum argenteum* and *Puccinellia distans* (Tables 3, 4).

Among seven other basic ruderal phytocenoses, however, *Puccinellia distans* occurs rarely and in scant numbers. This takes place in four associations: *Polygono-Bidentetum*, *Senecioni-Tussilaginetum*, *Erigeronto-Lactucetum*, *Potentilletum anserinae*, two subassociations: *Lolio-Plantagine-tum typicum*, *Polygono-Matricarietum discoideae typicum*, and in one community: with *Medicago lupulina* (Tables 2–5).

It follows from the data presented above that *Puccinellia distans* strongly avoids ruderal communities that primarily occur in rich habitats, constantly highly moistened. This applies to phytocenoses such as: *Chenopodietum ruderale*, *Balloto-Chenopodietum*, *Impatienti-Convolvuletum* and *Rudbeckio-Solidaginetum*. It then turns out that *Puccinellia distans* clearly avoids also phytocenoses that occur in dry and well-exposed habitats but characterized by a highly dense and luxuriant plant cover. This is exemplified by associations: *Tanacetum-Artemisietum*, *Echio-Melilotetum* and *Leonuro-Arcietum tomentosum*. In Tarnów the absence of *Puccinellia distans* stations in railroad trackage is puzzling. This may be mainly due to the frequent use of highly toxic chemicals for weeding out plants. It is possible that in Tarnów *Puccinellia distans* has so far failed to settle down in many of its favourable habitats. Moreover, stations with *Puccinellia distans* are very often accidentally destroyed when the street rims, squares and other sites are being cleaned. This takes place chiefly in the central, most built-up part of town (Fig. 1).

In Tarnów *Puccinellia distans* occurs exclusively on anthropogenic soils with very weakly formed profiles. Most frequently it is a loamy or loess substratum with a permanently hard-beaten and well-exposed surface, easily permeable, of the sandy-loamy-gravely type. Especially worth noting is the strong expansion of *Puccinellia distans* occurring on the floors of the Nitrogen Works' dried-out water sedimentation tanks, on the substratum of compact, up to several-meter thick lime sludge deposits with specific chemical properties (Table 1). It should be emphasized that phytocenoses with *Puccinellia distans* occur almost equally frequently in habitats with intermittent variable moistening or drying-out. It turns out that the soils investigated in phytocenoses characterized with the presence of *Puccinellia distans* have several significant properties (Table 1), (27). First of all, they are soils salted to a greater or lesser degree. It is worth noting that they have highly diversified, including toxic, concentrations especially of K_2O , P_2O_5 , $N-NO_3$, and Na and Cl ions. Furthermore, these are soils characterized most often by alkaline *pH* and by the predominantly low Ca content.

Table 5. Phytosociological structure: 4.2. sub-association *Polygono-Matricarietum discoideae puccinellietosum*, 5. — community with *Medicago lupulina*. (x) — as in Table 2

Number of community	4.		5.		Presence	Frequency
	2.	3.	4.	5.		
Number of record	52	53	62	61		
Date	96-08-15	96-08-14	96-08-16	96-08-15		
Area of plot in m ²	4	4	4	4		
Cover the layer in %	70	100	80	100		
	C	D	C	D		
Number of species in record	13	5	11	14		
	14	20	100	12		
	5	100	4	56		
	5	100	4	27		
	9	80	4	36		
	6	100	6	59		
	9	100	8	60		
	13	100	8	61		
	20	20	90	62		
I. Ch: Isoëto-Nanojuncetea						
Plantago intermedia	+	+	r	+	I	.
II. Ch: a - Molinio-Arrhenatheretea, b - Trifolium fragiferi-Agrostietalia, Agropyro-Rumicion crispi, c - Plantaginietalia majoris, Lolio-Plantaginion						
a Taraxacum officinale	+	+	+	+	III	+
a Trifolium repens	+	+	+	+	I	1
a Achillea millefolium	+	+	+	+	I	.
b Potentilla anserina	+	+	+	+	I	.
c Plantago major	1	+	+	+	I	1
c Lolium perenne	+	+	+	+	III	1
III. Ch: a - Polygono-Poëtales annuae, b - Puccinellion maritimae						
a Chamomilla suaveolens (Ch: ass. 4)	+	+	+	+	I	.
a Polygonum aviculare (Ch: ass. 4)	2	3	2	2	IV	.
a Bryum argenteum	+	+	2	+	II	.
a Poa annua	+	+	2	2	I	.
b Puccinellia distans	4	4	4	5	V	1
IV. Ch: a - Secalietea, b - Chenopodietea, c - Artemisietea						
a Matricaria maritima subsp. inodora	.	.	.	+	II	.
b Chenopodium album	r	+	.	.	I	.
b Sonchus oleraceus	.	.	.	+	I	.
b Lactuca serriola	.	+	.	.	I	.
b Echinochloa crus-galli	.	.	1	.	II	.
b Atriplex patula	.	.	r	.	II	.
c Artemisia vulgaris	+	+	+	+	III	1
c Daucus carota	r	.	.	+	II	1
c Tanacetum vulgare	.	.	+	.	.	1
c Solidago gigantea	.	.	+	.	r	1
V. Ch: a - Agropyreteae repentis, b - Sedo-Scleranthetea, c - Festuco-Brometea (x)						
a Cirsium arvense	.	.	.	+	I	1
b Ceratodon purpureus	.	.	+	.	II	1
VI. Others						
Agrostis capillaris	+	.	.	+	I	1
Conyza canadensis	.	.	.	+	II	1
Medicago lupulina (D: com. 5)	.	.	+	.	I	1
Species occurring in 1 record						
IIa - Phleum pratense 59/r, Holcus lanatus 61/+, Lotus corniculatus 62/+.						
IIb - Juncus compressus 45/+, IVb - Setaria pumila 44/+, Polygonum persicaria 61/+, Atriplex nitens 62/+, IVC - Pastinaca sativa 62/+, Va - Tus-silago farfara 62/1. Vc - Pimpinella saxifraga 62/+, VI - Brachythecium albicans 55/+, Convolvulus arvensis 60/+, Barbula unguiculata 62/1.						

The presented structure of the occurrence, ecology and expansion of *Puccinellia distans* in Tarnów is basically almost the same as the structure characterized earlier in other towns (10, 11, 20, 27)

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STRESZCZENIE

Przedstawiona struktura rozmieszczenia i warunków występowania gatunku *Puccinellia distans* na terenie Tarnowa jest w głównych zarysach taka sama jak scharakteryzowana wcześniej na przykładzie innych miast. Rośnie na terenie Tarnowa w wyniku przypadkowego jej zawleczenia na siedliskach ruderalnych, wtórnie zasolonych. Z dużym przybliżeniem należy potwierdzić, że proces ekspansji omawianej rośliny wiąże się z postępującym stopniem zasolenia podłoża w wyniku stosowania związków soli do odśnieżania. Na terenie Tarnowa pierwsze zawleczone stanowisko *Puccinellia distans* pojawiło się prawdopodobnie na przełomie lat osiemdziesiątych i dziewięćdziesiątych; na wymieniony okres wskazują wszystkie dotychczas opublikowane dane o florze i roślinności tego miasta.

Aktualnie na terenie Tarnowa *Puccinellia distans* występuje na kilkudziesięciu pojedynczych i grupowych stanowiskach (ryc. 1), najczęściej na obrzeżu bardziej ruchliwych szos. Stosunkowo najczęściej notowano ją w Tarnowie na terenie Zakładów Azotowych, następnie w rejonie przyfabrycznych osadników wodnych i na obrzeżu śmietnika miejskiego. Poza tym zwraca uwagę brak w Tarnowie stanowisk z *Puccinellia distans*, m.in. na torowiskach kolejowych i towarzyszących im placach przeładunkowych. Przyczynę prawdopodobnie stanowi niszczenie roślinności preparatami chemicznymi. Na terenie Tarnowa *Puccinellia distans* występuje w obrębie 9 fitocenz (tab. 2–5). Najliczniej rośnie ona w płatach 2 podzespołów (*Lolio-Plantaginetum puccinellietosum* i *Polygono-Matricarietum discoideae puccinellietosum*) i w 1 zbiorowisku (z *Bryum argenteum* i *Puccinellia distans*). W innych fitocenzach ruderalnych *Puccinellia distans* występuje rzadko i nielicznie. Odnosi się to do 4 zespołów: *Polygono-Bidentetum*, *Senecioni-Tussilaginetum*, *Erigeronto-Lactucetum*, *Potentillo anserinae*, 2 podzespołów: *Lolio-Plantaginetum typicum*, *Polygono-Matricarietum discoideae typicum* oraz do zbiorowiska — z *Medicago lupulina*.

Puccinellia distans na terenie Tarnowa występuje głównie na siedliskach korzystnie oświetlonych, najczęściej mezofilnych, rzadziej w dużym stopniu przesuszonych lub uwilgotnionych. Omawiana roślina zdecydowanie unika zbiorowisk o bujnie rozwiniętej warstwie roślinnej. Pokrywa glebowa w miejscach występowania *Puccinellia distans* cechuje się najczęściej nawierzchnią zbitą, przepuszczalną, typu piaszczysto-żwirowo-gliniastego. Gleby te wyróżniają się przede wszystkim mniejszym lub większym stopniem zasolenia, prawie jednakowym zasadowym odczynem pH , bardzo zróżnicowanymi zawartościami związków: K_2O , P_2O_5 , Na, N- NO_3 oraz stałą i niewielką zawartością związków Ca (tab. 1).

Ponadto na terenie Tarnowa na szczególną uwagę zasługuje występowanie *Puccinellia distans* na dnie przyfabrycznych wyschniętych osadników wodnych na twardym, grubym do kilku m podłożu osadzonego szlamu o specyficznych właściwościach chemicznych (tab. 1). *Puccinellia distans* występuje tam często, pojedynczo lub w zwarciu, wśród inicjalnego zbiorowiska z mszakami.